KANALKU, HASSELBORG, AND SITKOH SUBSISTENCE SOCKEYE SALMON STOCK ASSESSMENT, 2001 ANNUAL REPORT

By

Jan Conitz
and
Margaret Cartwright

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ABSTRACT

Portions of the spawning sockeye salmon populations in Kanalku Lake and Sitkoh Lake were estimated through observer counts and mark-recapture studies; age, length, and sex composition of these populations were estimated using standard measurements and scale sampling and analysis. Sockeye salmon fry populations in each lake were estimated using hydroacoustic and trawl sampling. Baseline information was collected on the physical characteristics and productivity of lake rearing habitat in each system using standard limnological sampling procedures. At Hasselborg River, only visual surveys and a small amount of age, length, and sex sampling were successfully carried out; the physical environment in the river mouth made other types of sampling difficult. Confirming community and agency concerns, Kanalku Lake appeared to have very low spawning escapement, and low sockeye salmon fry density. Kanalku Lake has a relatively deep euphotic zone compared to other organically stained lakes in Southeast Alaska, and the zooplankton density and biomass were low. Sitkoh Lake appeared to have a healthy escapement, with a mark-recapture estimate of sockeye salmon within a selected index area of 8,788 (95% CI 8,025–10,485). Sitkoh Lake had moderate sockeye salmon fry densities compared to other sockeye salmon rearing lakes in Southeast Alaska. It also appears to have healthy zooplankton populations with sufficient numbers of cladocerans *Daphnia* spp. and *Bosmina* spp., the preferred prey items, to support the sockeye salmon fry population. Visual inspection of adult sockeye salmon in the lower Hasselborg River indicated that the spawning population there is healthy, but the river conditions prevented a successful mark-recapture study. Good baseline information was obtained from the sampling conducted in 2001, but additional years of data will be needed to validate these results, document trends in populations and lake productivity over time, and set sustainable escapement goal ranges for each system.

INTRODUCTION

Kanalku Lake (ADF&G stream no. 112-67-58/60), Hasselborg River/Salt Lake (ADF&G stream no. 112-67-035), and Sitkoh Lake (ADF&G Stream no. 113-95-005) have been part of the traditional territories of the Angoon clans for as long as they have lived in the area (Goldschmidt and Haas 1946, 1998). These streams have supplied salmon to the people of Angoon and nearby villages as far back as the oldest traditions recount, and continue to be important subsistence systems with moderate annual sockeye salmon harvests. Boundaries of the traditional territories around Angoon have remained constant from pre-Euro-American contact through the present, and the people have maintained continuous harvesting cycles of the subsistence resources within these boundaries. However, harvest patterns were subject to periodic changes in response to socioeconomic and environmental changes. A physically and biologically diverse land base has allowed harvesters to choose from among different areas as circumstances changed (George and Bosworth 1988). In recent years, there has been concern about declining sockeye salmon returns and harvest opportunities in these traditional subsistence areas (Matt Kookesh, ADF&G, personal communication, 2001).

Kanalku Bay and Kanalku Lake are part of the Kootznahoo Inlet and Mitchell Bay territory that were traditionally owned by the Deisheetan clan (Goldschmidt and Haas 1946, 1998). Remains of a weir, and artifacts dated to at least 1,000 years ago have been found at the head of Kanalku Bay, showing a long continuity of subsistence activity and technology in this area (Moss 1989). From historic times to the present, this area is the one most frequently used by the people of Angoon for subsistence fishing and hunting; between 60–90% of Angoon households fished and hunted there each year from 1955–1984. Nearly all marine, freshwater, and terrestrial species utilized for subsistence can be found in this area. Kanalku Lake is the primary source of sockeye salmon in the Mitchell Bay area, and contributed 56% of the subsistence sockeye salmon harvest reported by Angoon residents from 1981–1986 (George and Bosworth 1988).

Salt Lake, like Kanalku Lake and Kanalku Bay and other parts of Kootznahoo Inlet and Mitchell Bay, belonged to the Deisheetan clan from the time Tlingit people first occupied the Angoon area until the late 19th century, when it and the head of Mitchell Bay were given over to the Teikweidi clan (Goldschmidt and Haas, 1946, 1998). There was a summer settlement on the shores of Hasselborg River throughout the 19th century, where salmon were harvested and processed for winter use, and there were at least four large smokehouses on the banks of the river. Shellfish remains found near the site of the historic smokehouses provide evidence of use by people from the Angoon area for over 1000 years (Moss 1989). The summer camp and smokehouses were moved into Mitchell Bay in the 20th century, but Salt Lake is still used by the Teikweidi clan and recognized in their oral tradition. Fishing methods commonly used in the early 20th century were traps and gaff hooks. A trap was located in a natural hole under the first upstream falls and caught salmon as they fell back after unsuccessful attempts to jump the falls. Hasselborg River/Salt Lake was designated as a permitted coho subsistence fishery for Angoon residents in 1981. A household survey the following year found that permit holders had lived on average for three decades in Angoon, and learned to fish in Salt Lake as a child or teenager from family members. Most people fished beach seines with a crew of two to six members and one or two skiffs. The majority of permit holders participated in other subsistence fisheries and also held commercial fisheries limited entry permits. The salmon caught at Salt Lake were distributed among crew members, who in turn distributed them widely to other family members and the community (George and Kookesh 1982).

Sitkoh Bay and Lake were once owned by the Ganaxadi clan, but were turned over to the Deisheetan when the Ganaxadi left the Angoon area (de Laguana 1960). There is a petroglyph in Sitkoh Bay that reportedly signifies this transfer, which took place prior to the arrival of Russians in Alaska. When some Sitka Tlingit fled from the Russians to Sitkoh Bay, the Angoon Deisheetan allowed them to establish a settlement and gave them some fishing rights there. In 1890 a crew fishing for the Redoubt cannery entered Sitkoh Bay and forcibly took over fishing in the most productive streams, backed by the U.S. military. In 1900, the Chatham Cannery was built in Sitkoh Bay, under an agreement with the Deisheetan, which nominally allowed the clan to retain ownership and control over the village and bay. The Deisheetan and others from Angoon and Sitka worked for the cannery, and maintained seasonal subsistence activities there, until the cannery closed in 1974 (Thornton et al. 1990). Angoon and some Sitka residents still go to Sitkoh Bay to fish for chinook salmon in the spring, and sockeye salmon in July; between 25–60% of Angoon residents reported using Sitkoh Bay for subsistence fishing each year between 1957 and 1984 (George and Bosworth 1988).

Subsistence harvests in these systems are currently estimated from information recorded by permit holders on their permits and returned annually to ADF&G. The system is voluntary and there is no independent verification of these catch figures. Household interviews were conducted by ADF&G Division of Subsistence in Angoon in the fall of 2001. Kanalku Bay has the largest subsistence effort in recent years, with fishing recorded by an average of 35 permit holders annually from 1985–2000, and an average total annual harvest of 969 sockeye salmon (Appendix A.1). At Hasselborg/Salt Lake, there was an average annual harvest of 43 sockeye and 209 coho salmon from 1985–2000, on an average of 11 permits (Appendix A.2). Annual harvests of coho salmon before 1985 ranged from 400 fish in 1971 to

2,500 in 1975, according to information from household surveys (George and Kookesh 1982). At Sitkoh Bay there has been a large drop in both effort and total sockeye salmon harvest since 1990 (Appendix A.3). An average of 396 sockeye salmon were harvested annually from 1985–1990 on an average of 31 permits, while from 1991–2000, only 35 sockeye salmon were harvested annually on just three permits, about one-tenth the former levels. There were two years, 1991 and 1993, with no recorded effort or harvest at Sitkoh Bay.

A limited amount of sport catch and harvest information is available from ADF&G Division of Sport Fish mail surveys (Appendix A.4). The Sitkoh system in particular is a popular sport fishing area, with the third highest freshwater fishing effort in the Sitka area, and two U.S. Forest Service public use cabins on the lake. Sport fishers there target mainly steelhead and cutthroat trout and Dolly Varden char (Yanusz, 1997). Hasselborg River is also a fairly popular sport fishing area, with some guided sport fishing; coho salmon are targeted at Hasselborg. Sockeye salmon are generally not targeted in the sport fisheries, but are instead caught incidentally and released; however, there have been high sport catches of sockeye salmon in some years at each system.

Historical commercial fishery data is available for Sitkoh Bay for some years between 1890 and 1930 (Appendix A.5). Within two decades of the start of commercial fishing, depletion of the sockeye salmon runs became evident. Commercial fishing closures began in Sitkoh Bay in 1926 to protect the runs (Rich and Ball 1933). There have been no directed commercial fisheries in Mitchell Bay (Kanalku and Salt Lake) or in the terminal areas at Sitkoh at least since Alaska statehood. Currently, a commercial purse seine fishery operates in Chatham Strait outside of Kanalku Bay/Kootznahoo Inlet, but it is thought that most of the Kanalku sockeye salmon are avoided due to their relatively early run (ADF&G Staff 2000). There is no way to distinguish Kanalku or Mitchell Bay sockeye salmon from other stocks harvested in the commercial fishery. Likewise, commercial seine fisheries operating in areas adjacent to Sitkoh Bay and targeting pink salmon catch an unknown number of sockeye salmon incidentally.

Escapement data for the Kanalku and Hasselborg systems are limited to aerial survey counts conducted opportunistically during other ADF&G Commercial Fisheries Division management surveys. These surveys are not considered reliable estimates of sockeye salmon populations due to variation in visibility, timing, and observers (Jones and McPherson 1997; Jones et al. 1998). The highest sockeye salmon counts in Kanalku Lake were 720 in 1993 and 500 in 1998; the peak counts in the lake were nearly always in early September. (Appendix B.1). Higher counts were recorded at the mouth of the outlet stream, but these may have included some pink salmon. The mix of species present in the Hasselborg River mouth made it difficult to count fish of any one species, and aerial survey counts were not possible during periods of high water (Appendix B.2).

Weirs were used at the outlet of Sitkoh Creek in 1936, 1937, 1982, 1990, and 1993, to count immigrating steelhead and emigrating cutthroat trout and Dolly Varden in the spring (Yanusz 1997). In 1982 and 1996 ADF&G operated adult salmon escapement weirs on Sitkoh Creek. In 1996 a mark-recapture estimate of sockeye salmon escapement was compared to the weir count and the results indicated that some fish were getting past the weir undetected. Mark-recapture studies alone were used to estimate escapement in 1996–2000 (Kelley and Josephson 1997; Cook 1998; Crabtree 2000, 2001). The average estimated escapement for those years was 10,600 sockeye salmon (Appendix B.3).

A small sample of sockeye salmon from Hasselborg River in 1989 indicated predominance of smolting at age-0, and over 95% of returning adults spending three years at sea (Appendix B.4). Among Sitkoh Lake sockeye salmon, age-1.3 was the predominant age class in most years sampled, and age 1.2 was the second largest age class, or occasionally the largest (Appendix B.5).

Lake ecology and limnology data were collected in single-year studies at Kanalku Lake in 1995 (Barto and Cook 1996) and Sitkoh Lake in 1992 (D. Barto, ADF&G, personal communication 2001). Results showed that both lakes are fairly typical of coastal Alaska sockeye salmon nursery lakes; both are organically stained, dimictic lakes with low nutrient concentrations, high flushing rates, and relatively high secondary production (Appendix B.6).

The Kanalku, Hasselborg, and Sitkoh Sockeye Salmon Project is one of eight new projects, initiated in 2001 and funded through the Federal Subsistence Fisheries Resource Monitoring Program, to assess significant subsistence sockeye salmon runs in southeast Alaska. The project will collect escapement and lake ecology data at each system to support long-term escapement goals that incorporate lake productivity modeling. The study plan includes an assessment of the lake's physical characteristics, which support primary production, and the secondary production of its zooplankton populations. Zooplankton are the main food source for sockeye salmon, and cladocerans are their preferred food within the zooplankton community. By estimating the biomass and number of zooplankton by species, we can evaluate whether food is a limiting factor for juvenile sockeye salmon in any of the sockeye salmon rearing lakes. The species composition over the season and between years may provide insight into how the zooplankton community responds to different fry densities and adult escapement levels. Juvenile population parameters, including density, size, and age composition, are indicators of sockeye salmon response to conditions within the lake and will be estimated. The escapement and age-composition data we are collecting, combined with subsistence permit harvest reports, will enable us to estimate spawner-recruit relationships. This report summarizes the sockeye salmon stock assessment data collected in the first year of the project.

OBJECTIVES

1) Index the annual sockeye salmon escapement into each lake with a precision of +/- 15%, with 90% confidence using a mark-recapture program.
2) Estimate the age, length, weight, and sex composition of the sockeye salmon in indexing samples from each lake such that these estimates are within 5%, 95% of the time.
3) Collect baseline data on in-lake productivity of each lake using established ADF&G limnological sampling procedures, which may include water chemistry, zooplankton sampling, hydroacoustic fry assessments, and smolt sampling.

Changes to Objectives

The precision estimates for the population variables to be estimated were incorrectly stated in the original objectives listed above. Objectives 1 and 2 will therefore be changed for the subsequent years of the project as follows:

1) Index or estimate the annual sockeye escapement into each lake, so that the estimated coefficient of variation is less than 15%.
2) Estimate the age, length, weight, and sex composition of the sockeye salmon in the mark-recapture samples from each lake, so that the estimated coefficient of variation is less than 5%.

A 95% confidence interval will also be reported for these population estimates, where appropriate.

METHODS

Study Sites

Kanalku Lake

Kanalku Lake (N 57°29.22' W 134°21.02') lies in a steep mountainous valley approximately 20 km southeast of Angoon. The watershed area is approximately 32 km^2, and there is one major inlet stream draining into the east end of the lake. The lake elevation is about 28 m, and a 1.7 km outlet stream drains into the east end of Kanalku Bay (Barto and Cook 1995). The lake surface area is about 113 hectares, the mean depth is 15 m and the maximum depth is 22 m (Figure 1). In addition to the sockeye salmon run (*Oncorhynhcus nerka*), a large number of pink salmon (*O. gorbuscha*) spawn in the lower part of the outlet creek and intertidal area. A few coho (*O. kisutch*) and chum salmon (*O. keta*) spawn in the Kanalku system, and resident populations of cutthroat trout (*Oncorhynchus clarki* spp.), Dolly Varden char (*Salvelinus malma*), and sculpin (*Cottus sp.*) are found in Kanalku Lake.

A falls approximately 8–10 m high about 0.8 km upstream from tidewater forms a partial barrier to migrating sockeye salmon. The U.S. Forest Service considered constructing a fishpass over the falls in the 1960s but finally recommended against it due to cost. In 1970 ADF&G, working with the U.S. Forest Service, blasted resting pools and a small channel in the falls bedrock to assist the migrating salmon.

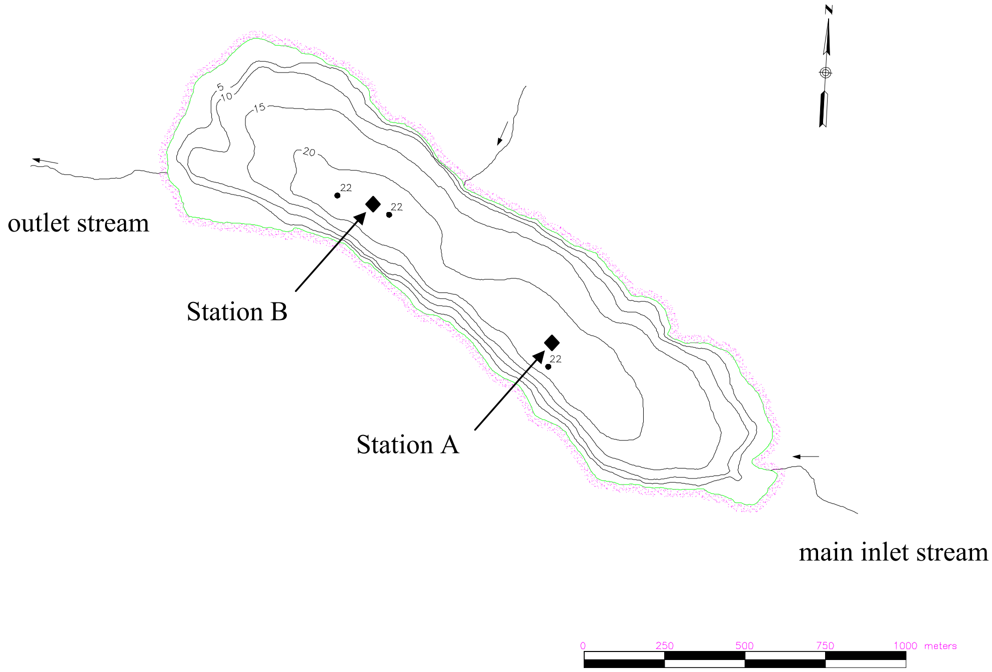

Figure 1. Bathymetric map of Kanalku Lake, showing two fixed sampling stations, and 5 m depth contour intervals.

Hasselborg River

Hasselborg Lake is 14 km long and the largest of a series of lakes covering a 55 km^2 area in the interior of Admiralty Island. Its outlet stream, Hasselborg River, flows for 13.3 km into the Salt Lake estuary (N 57°34.58' W 134°21.00') at the extreme east end of Mitchell Bay. Two barrier falls on Hasselborg River prevent sockeye and other salmon from reaching the lake. The lower falls is about 1.8 km above Salt Lake and about 5.5 m high; some migrating salmon are able to successfully jump the falls. The upper falls is about 2.5 km above the lower falls in a steep section of the valley and, at 9.2 m, forms a total barrier to fish passage. Salt Lake, a brackish water estuary, is separated from the rest of Mitchell Bay by a tidal falls, and can only be reached by boat during high tide. Sockeye, pink, chum, and coho salmon spawn in the Hasselborg River, and the Salt Lake drainage is the largest coho salmon producing system on Admiralty Island. Steelhead (*O. mykiss*) and cutthroat trout and Dolly Varden char are also present. Chinook salmon (*O. tshawytscha*) have been observed in Hasselborg River recently and are thought to be strays from Chatham hatcheries.

Sitkoh Lake

Sitkoh Lake (N 57°30.53' W 135°04.15') is located at the southeastern tip of Chichagof Island near the junction of Chatham and Peril Straits. The watershed area is about 31 km^2, and the lake elevation is approximately 59 m. The lake surface area is 189 hectares, the average depth is 20 m, and the maximum depth is 39 m (Figure 2). The outlet stream is about 6.4 km long and flows into Sitkoh Bay. The lake supports runs of sockeye, coho, pink, and chum salmon, as well as anadromous Dolly Varden char and cutthroat trout. The outlet creek supports one of the region's largest steelhead runs (Cook 1998). The Sitkoh drainage was extensively clear cut between 1969 and 1974.

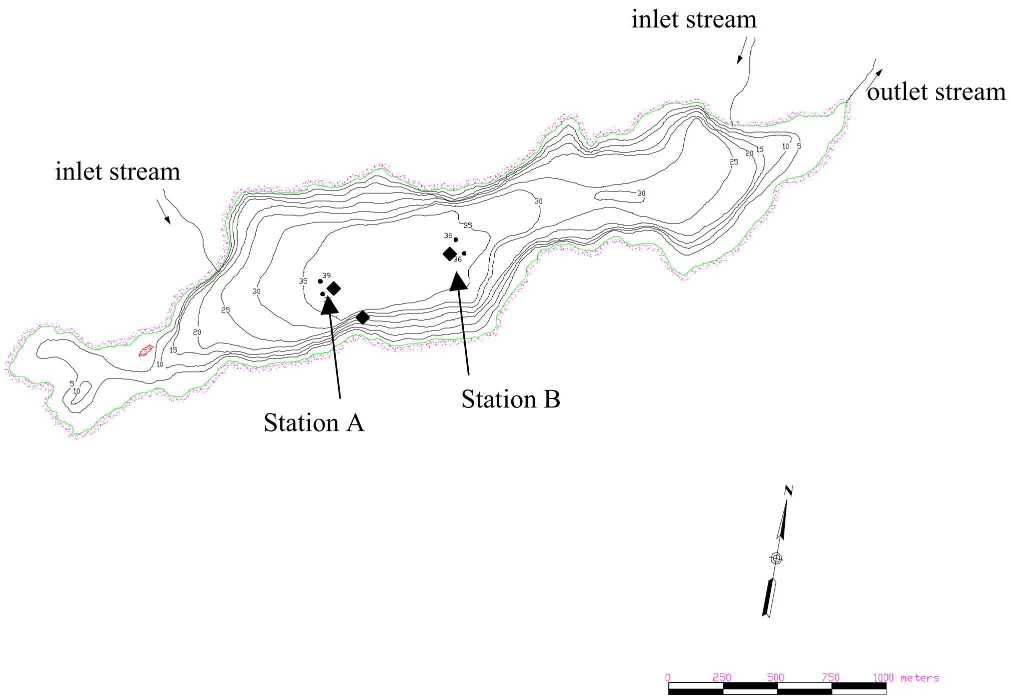

Figure 2. Bathymetric map of Sitkoh Lake, showing two fixed sampling stations, and 5 m depth contour intervals.

Sockeye Fry Population Assessment

The distribution and abundance of rearing sockeye salmon fry were estimated by hydroacoustic and mid-water trawl sampling. Sampling was conducted on 3 August 2001 in Kanalku Lake and on 4 August 2001 in Sitkoh Lake. Each lake was divided into seven sampling areas based on surface area, and hydroacoustic sampling was conducted on one randomly chosen orthogonal transect from each sampling area. These cross-lake transects were started and ended at a depth of 10 m from the shore and each transect was surveyed twice to get a replicate sample. A constant boat speed of about 2.0 m $\cdot$ sec^{-1} was attempted for all transects. A Biosonics DT-4000™ scientific echosounder[2] (420 kHz, 6° single beam transducer) was used with Biosonics Visual Acquisition© version 4.0.2 software to collect and record the data. Ping rate was set at 5 pings $\cdot$ sec^{-1} and pulse width at 0.4 ms. Data were analyzed using Biosonics Visual Analyzer© version 4.0.2 software. A target strength of –50 dB to –68 dB was used to represent fish within the size range of juvenile sockeye salmon and other small pelagic fish. A target density for each transect was

[2] Product names used in this publication are included for scientific completeness but do not constitute product endorsement.

applied to calculate a population estimate for each of the seven sampling areas. A total lake population estimate was obtained by summing the seven sampling area estimates. A second estimate was calculated using the replicate set of transects. The average between these two estimates was used as the total population estimate for each lake.

Trawl sampling was conducted in conjunction with hydroacoustic surveys to determine the species composition of targets. A 2 m × 2 m elongated trawl net was used to sample pelagic fish. Trawl depths and duration were determined by fish densities and distributions throughout the lake based on observations from the hydroacoustic survey. All captured fish were euthanized with MS-222 and preserved in 90% ethanol. In the laboratory, fish were soaked in water for 60 min before sampling. The snout-fork length was measured to the nearest millimeter (mm) and weight was measured to the nearest tenth gram (0.1g) on each fish. All sockeye salmon fry under 50 mm were assumed to be age- 0. Scales were collected from fish over 50 mm for age analysis. Sockeye salmon fry scale patterns were examined through the Carton microscope with a video monitor and aged using methods outlined in Mosher (1968). Two trained technicians independently aged each sample. The results of each independent scale ageing were compared, and in instances of discrepancy between the two age determinations, a third independent examination was conducted.

Adult Escapement Estimates

Mark-Recapture and Visual Survey

Four trips were scheduled to each study site every two weeks to conduct lake surveys and mark-recapture events. We observed that sockeye salmon at both Kanalku and Sitkoh Lakes were beach spawners. The Hasselborg River sockeye salmon appeared to be spawning in the main river channel. Actual sampling schedules were as follows:

Kanalku Lake	23 Aug.	survey only
	6 Sept.	survey and mark-recapture
	20 Sept.	survey and mark-recapture
	2 Oct.	no sockeye salmon observed
Hasselborg River	26 Aug.	survey and mark-recapture attempted but not completed
	23 Sept.	survey and mark-recapture attempted but not completed
Sitkoh Lake	28 Aug.	survey and mark-recapture
	9 Sept.	survey and mark-recapture
	26 Sept.	survey and mark-recapture
	10 Oct.	survey and mark-recapture
	24 Oct.	survey and mark-recapture

At the beginning of each trip to Kanalku and Sitkoh Lakes, the numbers of spawners in defined shoreline strata around the lake were estimated to provide an escapement index and describe the distribution of spawners (Figures 3 and 4). Only a rough estimate of total sockeye salmon was possible in Hasselborg River. At Kanalku and Sitkoh Lakes, mark-recapture index areas were selected where the majority of the fish were spawning, and the boundaries were recorded using Global Positioning Satellite (GPS). The mark-recapture studies were conducted only within these areas during subsequent trips.

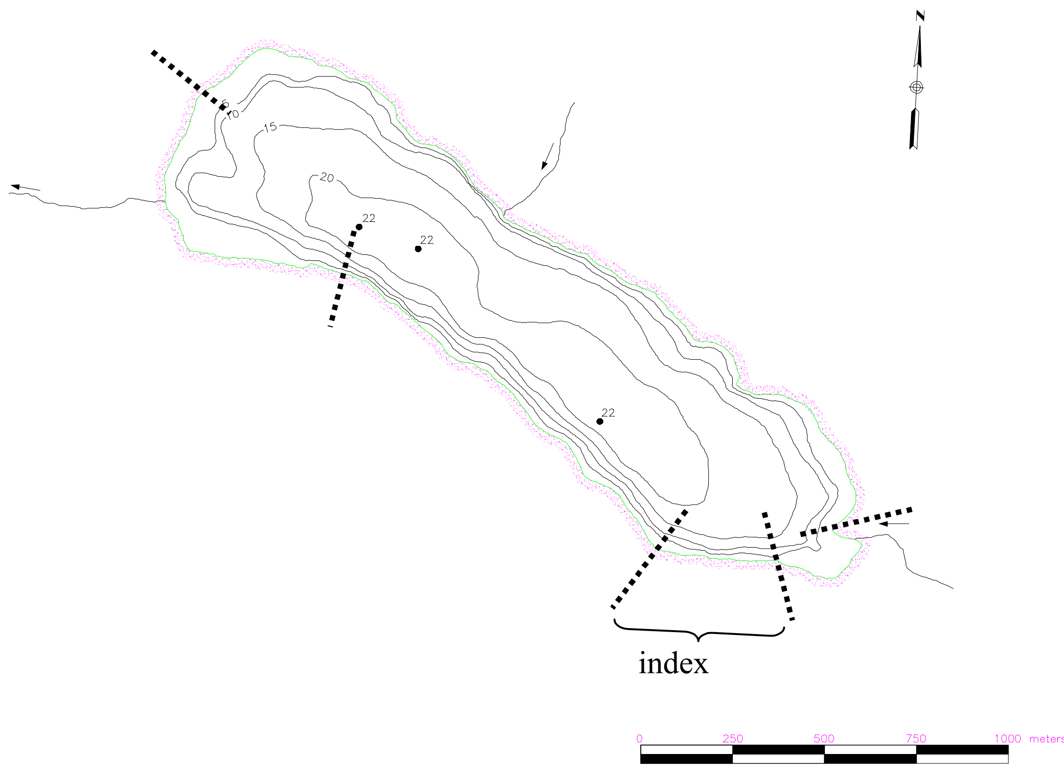

Figure 3. Map of Kanalku Lake showing index area where the mark-recapture study was conducted, and the endpoints of other strata used in the visual surveys, indicated by dashed lines.

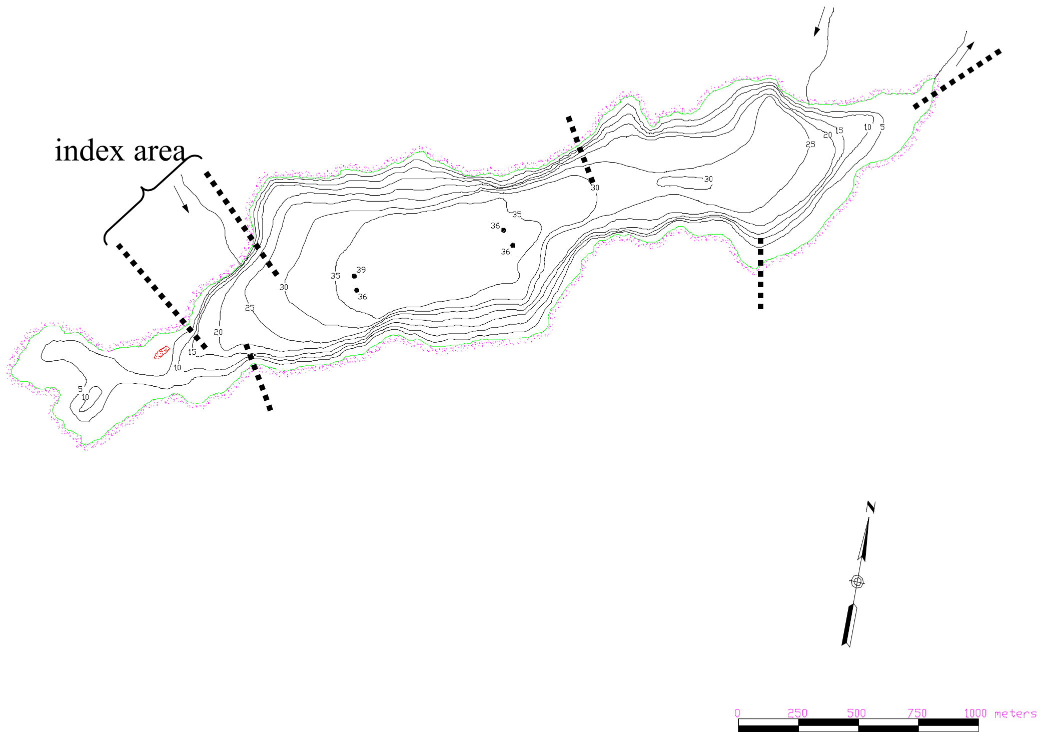

Figure 4. Map of Sitkoh Lake showing index area where the mark-recapture study was conducted, and the endpoints of other strata used in the visual surveys, indicated by dashed lines.

The study design consisted of two sampling stages: 1) a two-sample Petersen estimate for each trip (Seber, 1982) and 2) a multiple trip estimate using a modified form of the Jolly-Seber method for multiple mark-recaptures in an open population (Seber 1982; Cook 1998). In the first stage, fish were marked on one day and examined for marks the next day; simple Petersen population estimates were generated from these data (Seber 1982). In the second stage, fish caught on both days of a given trip were marked with a unique mark for that trip, and in subsequent trips, recaptures of these marks were recorded. The sampling across trips used the first stage Petersen estimates to generate a population estimate within the study area for the entire season. The resulting population estimate for the index area was then expanded to an escapement estimate for the entire lake or stream, based upon the visual survey counts.

A 20 m long and 4 m deep beach seine was used to surround sockeye salmon, pulled by a small skiff with outboard motor and crew members on foot. All sockeye salmon caught were first inspected for previous marks, then marked with an opercular punch or pattern of punches indicating the trip and day number, and released with a minimum of stress. The total sample size, the number of new fish marked, and the number of recaptured fish with each type of mark were recorded. Biological samples and measurements were taken from a subset of these sockeye salmon for age classification.

Data Analysis

The visual counts from each stratum were averaged across all observers, and the average counts from all strata inside and all strata outside the index area were summed. The number of observers varied from three to five. A bootstrap procedure was used to estimate the variance of counts between observers (X. Zhang, ADF&G, personal communication, 2001).

Chapman's form of the Petersen mark-recapture estimate and variance was used (Seber 1982, p. 60) for the first stage point population estimates within the index area. Confidence intervals for these estimators were estimated using the criteria given in Seber (1982, p. 63), according to sample size and marking fraction. If the criteria were met then Seber's eq. 3.4 was used; otherwise, the confidence interval bounds were found from Table 41 in Pearson and Hartley (1966).

In the second stage, the point population estimates, N^*_i, were used in a Jolly-Seber multiple mark-recapture estimator, in place of the derived parameter estimating the number of animals alive in the system at each sampling occasion. The N^*_i were also used in the estimation of two other parameters, B_i and M_i, below (Schwarz et al. 1993; Cook 1998; J. Blick, ADF&G, personal communication 1998). Given s sampling occasions.

N^*_i = number of fish alive in the system at sampling occasion i (the Chapman-Peterson point population estimates from the first stage),

n_i = number of unmarked fish and fish marked on previous trips, caught at sampling occasion i,

m_i = number of fish marked on previous trips, caught at sampling occasion i,

M_i = number of marked fish alive at time i,

ϕ_i = probability that a fish alive at time i is also alive at time $i+1$ (i.e. the survival rate)

B_i = number of fish that enter the system after occasion i and are still alive at time $i+1$ (i.e. immigration).

B^*_i = number of animals that enter the system after occasion i, but before occasion $i+1$,

N = total number of animals that enter the system before the last sampling occasion.

The specific intermediate estimates are:

$M_i = m_i N^*_i / n_i,$

$\phi_i = M_{i+1}/(M_i - m_i + n_i),$

$B_i = N^*_{i+1} - \phi_i N^*_i.$

B^*_i $(for\ 1 < i < s\text{-}1) = B_i log(\phi_i)/(\phi_i\text{-}1),$ where recruitment and mortality are assumed to be uniform between times i and i+1.

Because B_0, B_1, and B_{s-1} are not uniquely estimable, B_{s-1} was set to zero, assuming the sampling extended to the point where recruitment was virtually ended, and $B^*_0 + B^*_1$ was estimated by $N_2 log(\phi)/(\phi\text{-}1)$. The total abundance N was then estimated as:

$N = \Sigma B^*_i$ (Schwarz et al. 1993; Cook 1998; J. Blick, ADF&G, personal communication 1998).

A bootstrap method was used to estimate the confidence interval for this estimator. This was based on two random variables: the number of marked fish caught in the second sample of the first stage mark-recapture as a random variable with hypergeometric distribution, and the number of marked fish caught in the second stage mark-recapture as a random variable with normal distribution (X. Zhang, ADF&G, personal communication 2002).

Linear regression was used to compare mark-recapture escapement estimates to visual counts within the index areas across all sampling dates in four lakes studied during the 2001 season (X. Zhang, ADF&G, personal communication 2002). Mark-recapture and observer count data from four lakes in the Chatham Strait region (Kook, Sitkoh, Kanalku, and Falls Lakes) were pooled since there were insufficient data from any one lake in this first sampling season with which to estimate a regression. The four lakes included in this regression had similar water color, shoreline characteristics, and spawning areas used by sockeye salmon. The slope obtained from this regression was 2.02 with an R^2 value of 0.94; this slope was used to predict escapement for the whole lake from the visual count for the whole lake.

Adult Sockeye Salmon Population Age and Size Distribution

The age composition for brood year analysis was determined from a set of scale samples and length measurements collected from mark-recapture samples during each trip. The target number of biological samples for each system was 600 for this season. At Sitkoh Lake, 492 sockeye salmon were sampled for scales (age), length and sex. At Kanalku Lake, 84 sockeye salmon were sampled, the small number due to very low escapement. At Hasselborg River, 44 sockeye salmon were sampled. Three scales were taken from the preferred area of each fish (INPFC 1963), and prepared for analysis as described by Clutter and Whitesel (1956). Standard ADF&G procedures were followed in collecting the scales and recording data (ADF&G Staff 2001). Age and length data were paired for each fish sample. Mid-eye to fork length was measured to the nearest millimeter. All scale analysis was conducted at the ADF&G, Commercial fisheries aging lab in Douglas, Alaska.

Limnology

Limnology sampling was scheduled for Kanalku and Sitkoh Lakes at six-week intervals from mid-May through October, for a total of four sampling dates. We did not conduct limnology sampling in Hasselborg River. Two stations were set up in each lake at the deepest part of the lake, and separated as widely as possible. Physical data were collected from only one station. Only light intensity, and not temperature and dissolved oxygen, were measured on the May sampling dates. Zooplankton samples were collected from both stations on each sampling date.

Light, Temperature, and Dissolved Oxygen Profiles

The depth at which underwater light intensity is attenuated to one percent of its value just below the surface defines the area of the lake where photosynthesis is possible. We recorded underwater light intensity (footcandles) at 0.5 m intervals, from just below the surface to a depth equivalent to one percent of the sub-surface light reading, using a Protomatic submarine photometer. Vertical light extinction coefficients (K_d) were calculated as the slope of the light intensity (natural log of percent subsurface light) versus depth. The euphotic zone depth (EZD) is defined as the depth to which one percent of the subsurface light [photosynthetically available radiation (400-700nm)] penetrates the lake surface (Shindler 1971), and was calculated from the equation: $EZD = 4.6205/ K_d$ (Kirk 1994).

Temperature and dissolved oxygen (DO) profiles were measured with a Yellow Springs Instruments (YSI) Model 58 DO meter and probe, calibrated each sampling trip with a 60 ml Winkler field titration (Koenings et al. 1987). Relative (%) and absolute (mg L^{-1}) DO values were recorded; temperature values were in ºC. Measurements were made at 1 m intervals to the first 10 m or the lower boundary of the thermocline (defined as the depth at which the change in temperature decreases to less than 1ºC per meter), and thereafter at 5 m intervals to within 2 m of the bottom (or 50 m).

Secondary Production

Zooplankton are the primary food for sockeye salmon and cladocerans are the preferred food within the zooplankton community. By estimating the biomass and number of zooplankton by species throughout the season, we can observe how the species composition changes over the season and between years. This information may provide insight into how the zooplankton community responds to different fry densities and adult escapement levels. Zooplankton samples were collected at two stations each on Kanalku and Sitkoh Lakes using a 0.5 m diameter, 153 um mesh, 1:3 conical net. Vertical zooplankton tows were pulled from a depth of 2 m above the bottom at each station, at a constant speed of 0.5 m sec^{-1}. The net was rinsed prior to removing the organisms, and all specimens were preserved in neutralized 10% formalin (Koenings et al. 1987). Zooplankton samples were analyzed at the ADF&G, Commercial Fisheries Limnology Laboratory in Soldotna, Alaska. Cladocerans and copepods were identified using the taxonomic keys of Brooks (1957), Pennak (1978), Wilson (1959), and Yeatman (1959). Zooplankton were enumerated from three separate 1 ml subsamples taken with a Hensen-Stemple pipette and placed in a 1 ml Sedgewich-Rafter counting chamber. Zooplankton body length was measured to the nearest 0.01 mm from at least 10 organisms of each species along a transect in each of the 1 ml subsamples using a calibrated ocular micrometer (Koenings et al. 1987). Zooplankton biomass was estimated using species-specific dry weight versus zooplankter length regression equations (Koenings et al. 1987). The seasonal mean density and body size was used to calculate the seasonal zooplankton biomass (ZB) for each species. Marco-zooplankters were further separated by sexual maturity where ovigorous (egg bearing) zooplankters were also identified.

RESULTS

Juvenile Sockeye Population Assessment

Hydroacoustic surveys were completed in Kanalku and Sitkoh Lakes on 3 and 4 August, respectively. Three 25-min trawl tows were conducted in Kanalku Lake, at 5 and 10 m, and only one sockeye salmon fry was caught (Table 1). A total lake population of 9,000 sockeye salmon fry was estimated from the hydroacoustic survey, and the sockeye salmon fry density was estimated to be 0.010 fry$\cdot$m^{-2}. In Sitkoh Lake, a total of 91 fish were caught in two 30-min trawl tows at 10 m and all were sockeye fry. A total lake population of 182,000 sockeye salmon fry was estimated from the hydroacoustic survey, and the sockeye fry density was estimated to be 0.122 fry $\cdot$ m^{-2}. Although some of the Sitkoh Lake sockeye salmon fry were larger than 50 mm, scale analysis showed 100% of those sampled were age-0 (Figure 5).

Table 1. Abundance, size, and age distribution of sockeye salmon fry in Kanalku and Sitkoh Lakes, 2001.

Lake	Species	Age	Sample Size	Proportion of Total	Mean Length (mm)	Mean Weight (g)	Total Population
Kanalku	Sockeye	0	1	100%	53.5	1.50	9,000
Sitkoh	Sockeye	0	91	100%	41.9	0.7	182,000

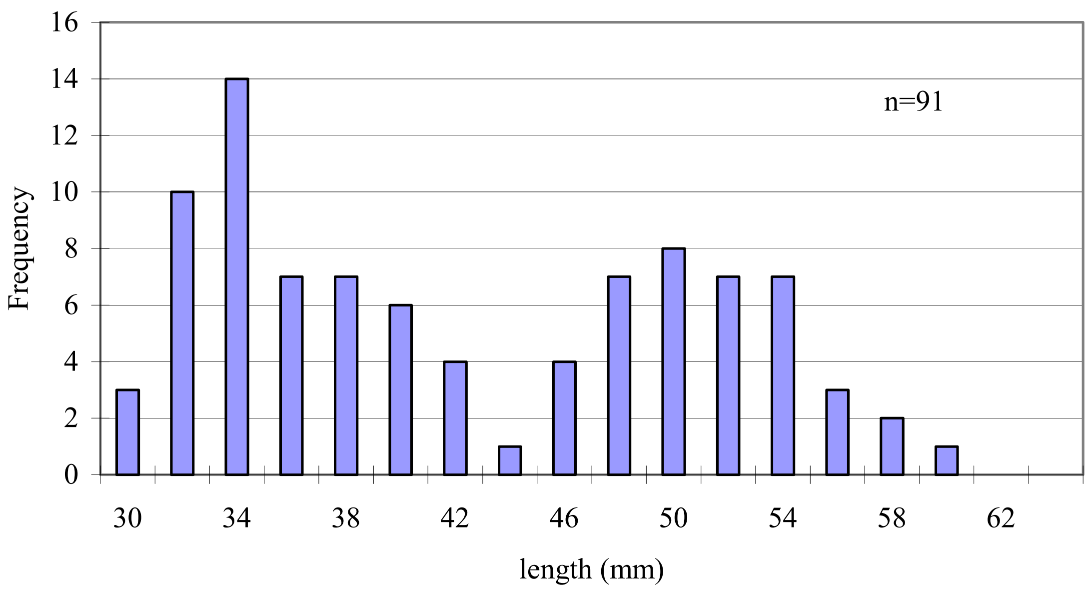

Figure 5. Length frequency distribution of sockeye salmon fry in Sitkoh Lake, 2001. Fish under 50 mm in length were assumed to be age-0 and scale analysis showed all fish in these samples over 50 mm were also age-0.

Adult Escapement Estimates

Mark-Recapture and Visual Survey

We had varying success in estimating the adult returns to the three systems. We were only able to sample on two trips at Kanalku Lake, and because of low numbers of fish present, the mark and recapture samples each trip were very small (Table 2). Consequently, the confidence interval (CI) around the population estimate was large and precision was low. The estimate of total sockeye salmon escapement within the index area at Kanalku Lake was 219 fish, and the expanded whole lake estimate was only 229 fish (Table 4). The first scheduled mark-recapture event was missed because we could not determine if this was a beach or stream spawning system. Although a small number of sockeye salmon were staged at the mouth of the stream, no sockeye salmon were seen in the inlet stream. We decided to wait until the next sample period and observe the spawners again to determine whether the mark-recapture study should be conducted in the stream or on the lake shore. Two complete mark-recapture events were subsequently completed after we determined that the majority of sockeye salmon were beach spawners. No sockeye salmon were observed on the fourth trip.

Table 2. Summary of mark-recapture samples in Kanalku Lake, 2001. Marks were opercular punches; the different shapes indicate the trip number for the modified Jolly-Seber escapement estimate. Point estimates of the number of sockeye spawners present on each trip were generated from the number of fish recaptured in a sample on the second day out of those marked in a sample on the first day. A secondary opercular punch mark was used to prevent recounting of fish already captured on a given day.

			New fish marked:			Recaptures			
Trip #	Starting Date	Mark Type	Day 1	Day 2	Both Days	C	TRI	SQ	Total sample Day 2
1	23 Aug	-	-	-	-				-
2	6 Sept	circle (C)	52	34	86	13			47
3	20 Sept	triangle (TRI)	26	12	38	6	3		15
4	2 Oct	square SQ)	0	0	0	0	0	0	0

At Sitkoh Lake, five mark-recapture sampling events were accomplished and sample sizes were large enough to estimate escapement within the desired range of precision (Table 3). We estimated 8,788 sockeye salmon within the index area and the expanded estimate was 12,209 for the whole lake (Table 4).

Table 3. Summary of mark-recapture samples in Sitkoh Lake, 2001. See Table 2 for mark explanations.

Trip #	Starting Date	Mark type	New fish marked: Day 1	Day 2	Both Days	Recaptures: C	TRI	SQ	2C	2TRI	Total sample Day 2
1	28 Aug	circle (C)	281	171	452	125					296
2	9 Sept	triangle (TRI)	277	134	411	98	125				259
3	26 Sept	square (SQ)	679	215	894	0	15	334			549
4	10 Oct	2 circ.(2C)	370	239	609	0	3	32	121		360
5	24 Oct	2 trian. (2TRI)	149	164	313	0	2	4	19	69	233

A mark-recapture study was attempted at Hasselborg River, but since the fish were widely scattered throughout the lower river and very mobile, it was extremely difficult to define an index area and obtain repeatable samples. Beach seines proved not to be an effective way to capture fish in this river system. Consequently no estimate of the number of adult sockeye salmon is available.

Table 4. Survey counts and mark-recapture estimates with 95% confidence intervals in Kanalku Lake, Hasselborg River, and Sitkoh Lake for 2001.

Lake	Trip Date	Visual Count, Entire Lake ± se	Visual Count, Index Area	Petersen Estimate, Index Area (95% CI)
Kanalku	8/23	169 ± 3	na	na
	9/6	134 ± 9	132	187 (121 - 325)
	9/20	56 ± 5	45	107 (55 - 578)
	10/2	0	0	0
	modified Jolly-Seber escapement estimate for index area[a]			217 (145 - 324)
	expanded escapement estimate for whole lake[a, b]			229 (142 – 411)
Hasselborg R.	8/26	2500	na	na
	9/23	250	na	na
Sitkoh	8/28	523 ±73	303	664 (603 - 742)
	9/10	655 ±24	315	573 (523 - 636)
	9/26	1146 ±82	599	1115 (954 - 1,072)
	10/10	549 ±11	429	1097 (988 - 1,300)
	10/24	410 ±22	291	500 (437 - 593)
	modified Jolly-Seber escapement estimate for index area[a]			8,788 (8,025 - 10,485)
	expanded escapement estimate for whole lake[a, b]			12,209 (10,795 - 16,998)

[a] 95% confidence intervals are indicated.
[b] Expanded whole lake escapement estimates should be considered preliminary (see Discussion section)

Adult Sockeye Salmon Population Age and Size Distribution

In Kanalku Lake, only a small sample of 121 adult sockeye salmon could be obtained for analysis of age and size distribution due to low escapement. Of these fish, ages could only be determined for 98; the others had regenerated scales. Nearly 98% of the fish that could be aged were age-1.2 (54%) or age-1.3 (44%) (Table 5.a). The remainder were age-2.2 fish. The average length of males was 525 mm and the average length of females was 498 mm, and the average length of all sockeye salmon in this sample was 506 mm. Age-1.2 fish were considerably smaller, averaging 474 mm, than age-1.3 fish, which averaged 538 mm (Table 5.b).

Table 5a. Age composition of sockeye salmon sampled from the Kanalku Lake escapement from 7–21 September 2001.

Brood Year	**1997**	**1996**	**1996**	
Age	**1.2**	**1.3**	**2.2**	**Total**
Male				
Sample Size	12	28	2	42
Percent	13.5	31.5	2.2	47.2
Std. Error	2.9	4	1.3	4.3
Female				
Sample Size	36	11		47
Percent	40.4	12.4		52.8
Std. Error	4.2	2.8		4.3
All Fish				
Sample Size	48	39	2	89
Percent	53.9	43.8	2.2	100
Std. Error	4.3	4.2	1.3	

Table 5b. Mean fork length (mm) of sockeye salmon sampled from the Kanalku Lake escapement from 7–21 September 2001, by sex and age class.

Brood Year **Age**	**1997** **1.2**	**1996** **1.3**	**1996** **2.2**	**not aged**	**Total**
Male	482	539	478	538	525
Std. Error	7.4	2.7	12.5	5.1	4.0
Sample Size	12	28	2	16	58
Female	472	535		494	489
Std. Error	2.5	9.8		7.1	4.1
Sample Size	36	11		16	63
All	474	538	478	516	506
Std. Error	2.7	3.3	12.5	5.9	3.3
Sample Size	48	39	2	32	121

Only a very small sample of adult sockeye salmon was obtained at Hasselborg River due to difficulties with capture methods. Scales and length measurements were taken from 44 fish, but no age could be determined for 30 of those fish because the scales were regenerated (Table 6.a). Of the 14 fish that were aged, there was one male age-1.2 and 13 females age-1.3. The average length of all 44 fish was 549 mm, with males averaging 590 mm and females averaging 536 mm (Table 6.b).

Table 6a. Age composition of sockeye salmon sampled from the Hasselborg River escapement on 23–24 September 2001.

Brood Year	**1997**	**1996**	
Age	**1.2**	**1.3**	**Total**
Male			
Sample Size	1		1
Percent	7.1		7.1
Std. Error	7.1		7.1
Female			
Sample Size		13	13
Percent		92.9	92.9
Std. Error		7.1	7.1
All Fish			
Sample Size	1	13	14
Percent	7.1	92.9	100
Std. Error	7.1	7.1	

Table 6b. Mean fork length (mm) of sockeye salmon sampled from the Hasselborg River escapement on 23–24 September 2001.

Brood Year	**1997**	**1996**		
Age	**1.2**	**1.3**	**not aged**	**Total**
Male				
Av. Length	530		597	590
Std. Error	na		2.2	2.1
Sample Size	1		10	11
Female				
Av. Length		537	534	536
Std. Error		5.0	0.9	0.7
Sample Size		13	20	33
All Fish				
Av. Length	530	537	555	549
Std. Error		5.0	1.2	0.9
Sample Size	1	13	30	44

An adequate sample size of 492 adult sockeye salmon was obtained at Sitkoh Lake. Of these fish, ages could not be determined for 82, because the scales were regenerated. Among those fish aged, age-1.3 was the dominant age class, comprising almost 93% of the sample (Table 7.a). About 5% of the sample were age-1.2, and there were a few age-1.1 jacks. Males and females were close in size (Table 7.b). In the dominant age-1.3 class, males averaged 559 mm and females averaged 547 mm. Overall, the average length of males was 551 mm and the average length of females was 544 mm.

Table 7a. Age composition of sockeye salmon sampled from the Sitkoh Lake escapement from 29 August – 24 October 2001.

Brood Year	**1998**	**1997**	**1997**	**1996**	**1995**	
Age	**1.1**	**0.3**	**1.2**	**1.3**	**2.3**	**Total**
Male						
Sample Size	5	1	14	208	2	230
Percent	1.2	0.2	3.4	50.6	0.5	56
Std. Error	0.5	0.2	0.9	2.4	0.3	2.4
Female						
Sample Size			8	172	1	181
Percent			1.9	41.8	0.2	44
Std. Error			0.7	2.4	0.2	2.4
All Fish						
Sample Size	5	1	22	381	3	412
Percent	1.2	0.2	5.3	92.5	0.7	100
Std. Error	0.5	0.2	1.1	1.3	0.4	

Table 7b. Mean fork length (mm) of sockeye salmon sampled from the Sitkoh Lake escapement from 29 August – 24 October 2001.

Brood Year	**1997**	**1998**	**1997**	**1996**	**1995**		
Age	**0.3**	**1.1**	**1.2**	**1.3**	**2.3**	**No Age**	**Total**
Male	570	351	481	559	578	556	551
Std. Error		8.7	4.6	1.8	12.5	3.5	2.4
Sample Size	1	5	14	206	2	48	276
Female			488	547	550	546	544
Std. Error			3.0	1.4		3.6	1.5
Sample Size			8	172	1	34	215
All	570	351	483	554	568	552	548
Std. Error		8.7	3.1	1.2	11.7	2.6	1.5
Sample Size	1	5	22	379	3	82	492

Limnology

Limnology sampling was conducted on 24 May, 5 July, 25 August, and 19 October on Kanalku Lake. The sampling in Sitkoh Lake was conducted 16 May, 7 July, 3 September, and 17 October.

Light, Temperature, and Dissolved Oxygen Profiles

The mean euphotic zone depth was approximately 11 m and 7 m in Kanalku and Sitkoh Lake, respectively (Table 8). Euphotic zone depth in Kanalku was shallowest in fall and spring. During those seasons, more suspended particulate matter may be in the lake because of greater turbulence from storms, water column mixing, and higher sediment input from runoff. The same pattern exists in the Sitkoh data but is much less pronounced.

Table 8. Euphotic zone depth in Kanalku and Sitkoh Lakes, 2001.

Lake	Date	EZD (m)
Kanalku	24-May	8.80
	5-Jul	15.66
	25-Aug	13.46
	19-Oct	6.32
	seasonal mean	11.06
Sitkoh	16-May	6.32
	7-Jul	7.84
	3-Sep	7.74
	17-Oct	4.86
	Seasonal Mean	6.69

Water temperature vertical profiles for Kanalku and Sitkoh Lakes in 2001 show the thermal stratification pattern typical of dimictic lakes (Figure 6). A weak thermocline had formed in Kanalku Lake at about 7–8 m by late August. In Sitkoh Lake, which is deeper, the thermocline had formed by early July at about 10–12 m and deepened to about 13–15 m by early September. In mid October, Kanalku Lake was isothermic at about 7º C, and Sitkoh Lake was nearly isothermic at about 8.5º C down to 20 m. The maximum epilimnetic temperatures were 14.5^o C in Kanalku Lake on 25 August and 14.7^o C in Sitkoh Lake on 7 July. Hypolimnetic temperatures were about 6^o C in both lakes. Dissolved oxygen (DO) profiles were fairly uniform in each lake, remaining above 9.7 mg · L^{-1} throughout the season in both lakes (Appendix C.1, C.2), except for an October minimum of 8.3 mg · L^{-1} at the deepest depth (35 m) in Sitkoh Lake.

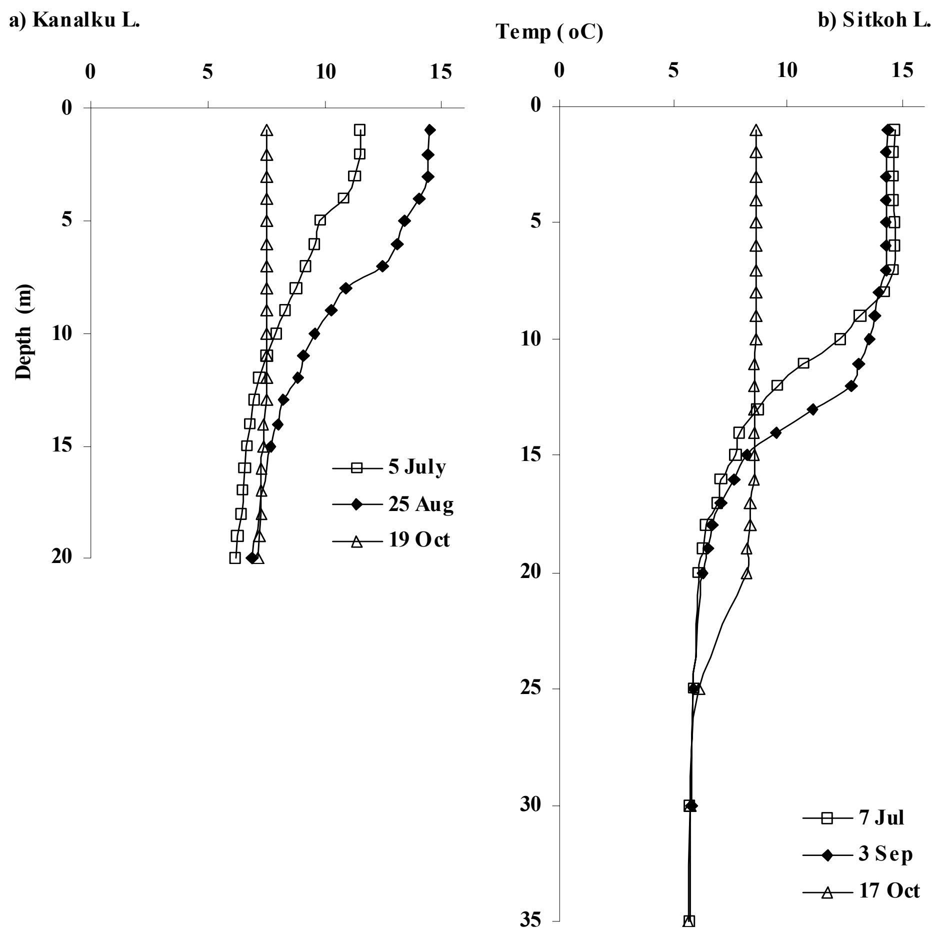

Figure 6. Water temperature vertical profiles for a) Kanalku and b) Sitkoh Lakes, 2001.

Secondary Production

Zooplankton abundance was nearly three times higher in Sitkoh than in Kanalku Lake, and zooplankton biomass in Sitkoh Lake was about twice as high as in Kanalku Lake (Table 9 and 10). However, species richness was greater in Kanalku Lake, with seven species identified in the samples; five species were identified in samples from Sitkoh Lake (Table 9 and 10; Appendix C.3, C.5). *Cyclops* dominated the zooplankton composition in Sitkoh Lake (64%) whereas *Cyclops* and *Bosmina* equally dominated in Kanalku Lake. The larger *Daphnia longiremus* was also relatively abundant in both lakes, and accounted for the second highest proportion of biomass in Kanalku Lake and the third highest in Sitkoh Lake (Tables 9 and 10; Appendix C.4, C.6). Peak abundance of *Cyclops* was in the spring in both lakes and again in late fall in Kanalku Lake. Peak abundances of the cladocerans *Bosmina* and *Daphnia* occurred in mid to late summer in both lakes (Appendix C.3, C.5). Body sizes of both cladocerans were moderately large in both lakes, but larger, on average, in Kanalku Lake. Seasonal mean weighted length of *Bosmina* was 0.53 mm in Kanalku and 0.49 mm in Sitkoh Lake, and ovigerous *Bosmina* were an average of 0.050 mm and 0.13 mm longer, respectively. Seasonal mean weighted length of *Daphnia longiremus* was 0.95 mm in Kanalku and 0.73 mm in Sitkoh Lake, and ovigerous *D. longiremus* were an average of 0.20 mm longer in both lakes (Appendix C.4, C.6).

Table 9. Species distributions of macro-zooplankton in Kanalku Lake, 2001. Zooplankton densities (number · m^{-2}) and mean weighted biomass (mg · m^{-2}) are seasonal mean values from four samples, collected at six week intervals May through October, at two permanent sampling stations. Ovigorous (egg-bearing) individuals in each taxa were enumerated separately.

Station A	**Density (no. · m^{-2})**	**Percent of total numbers**	**Biomass (mg · m^{-2})**	**Percent of total biomass**
Ergasilus	0			
Epischura	3,430	3%	43	11%
Diaptomus	2,721	2%	13	3%
Ovig. Diaptomus	94	0%	1	0%
Cyclops	43,666	32%	76	19%
Ovig. Cyclops	4,207	3%	21	5%
Bosmina	41,603	31%	112	28%
Ovig. Bosmina	2,955	2%	11	3%
Daphnia l.	20,636	15%	87	22%
Ovig. Daphnia l.	5,001	4%	29	7%
Holopedium	310	0%	3	1%
Ovig. Holopedium	68	0%	1	0%
Sida crystalina	0	0%	0	0%
Copepod nauplii	9,870	7%		
Total	**134,561**		**397**	
Station B				
Ergasilus	0	0%	19	6%
Epischura	2,683	2%	18	5%
Diaptomus	2,759	2%	8	2%
Ovig. Diaptomus	798	1%	48	14%
Cyclops	38,920	30%	10	3%
Ovig. Cyclops	2,089	2%	110	32%
Bosmina	43,199	33%	5	1%
Ovig. Bosmina	1,155	1%	99	29%
Daphnia l.	25,514	19%	23	7%
Ovig. Daphnia l.	3,592	3%		0%
Holopedium	713	1%	4	0%
Ovig. Holopedium	0	0%	0	
Sida crystalina	0	0%	0	
Copepod nauplii	9,926	8%		
Total	**131,347**		**345**	

Table 10. Species distributions of macro-zooplankton in Sitkoh Lake, 2001. Zooplankton densities (number · m^{-2}) and mean weighted biomass (mg · m^{-2}) are seasonal mean values from four samples, collected at six week intervals May through October, at two permanent sampling stations. Ovigorous (egg-bearing) individuals in each taxa were enumerated separately.

Station A	**Density (no. · m^{-2})**	**Percent of total numbers**	**Biomass (mg · m^{-2})**	**Percent of total biomass**
Ergasilus	0	0%		
Epischura	0	0%		
Diaptomus	0	0%		
Cyclops	202,836	53%	304	42%
Ovig. Cyclops	4,840	1%	15	2%
Bosmina	117,444	31%	259	36%
Ovig. Bosmina	3,227	1%	10	1%
Daphnia l.	37,697	10%	84	12%
Ovig. Daphnia l.	5,116	1%	20	3%
Holopedium	6,495	2%	31	4%
Ovig. Holopedium	170	0%	2	0%
Copepod nauplii	1,465	0%		
	379,288		**724**	
Station B				
Ergasilus	0	0%		
Epischura	0	0%		
Diaptomus	0	0%		
Cyclops	215,543	64%	280	49%
Ovig. Cyclops	4,047	1%	4	1%
Bosmina	80,659	24%	179	31%
Ovig. Bosmina	2,972	1%	8	1%
Daphnia l.	24,000	7%	57	10%
Ovig. Daphnia l.	5,066	1%	20	4%
Holopedium	4,415	1%	14	2%
Ovig. Holopedium	594	0%	6	1%
Copepod nauplii	906	0%		
	338,201		**569**	

DISCUSSION

Kanalku Lake

During this first year of the Subsistence Sockeye Salmon Project at Kanalku Lake, we were moderately successful in completing the three objectives for the project: estimating fry and adult abundance, describing the size and age structure of the fry populations, and establishing baseline information on the productivity of the lake. Our inability to complete the objectives is due mostly to the low number of juvenile and adult sockeye salmon present in the lake. For example, the coefficient of variation around the estimate of the total adult sockeye salmon population returning exceeded 15%. Because of the low number of adults returning to the lake, sample sizes were small and few fish were recaptured between sampling events. However, we think the sample sizes in the second and third mark-recapture events were adequate to obtain two good Petersen estimates of the number of sockeye salmon present at the study site at a given time. These estimates can be used as indices of escapement, and will show trends in escapement over time as we collect more data.

The most important result of this study is the documentation of very low sockeye salmon escapement into Kanalku Lake in 2001. The low density of sockeye fry in Kanalku Lake this year suggests that adult sockeye salmon returns in 2000 were also low. Although egg to fry survival in the winter of 2000–2001 could also account for low fry densities, this is not likely. A 1995 hydroacoustic estimate of sockeye salmon fry in Kanalku Lake reported a density 92% higher than in 2001 (Barto and Cook 1995), suggesting that the adult returns have declined considerably in the last six years. In addition, no human activity has occurred in the drainage that would reduce the amount of area available in the stream and beach habitats for spawning. This would suggest that the decline is due to a reduction in escapement. The commercial seine fishery typically starts at the end of June, minimizing the number of Kanalku sockeye salmon harvested prior to the subsistence fishery (Figure 7). Residents of Angoon are also concerned about the lack of sockeye salmon returning in the past few years. Preliminary results of this study prompted the reformation of the Fish and Game Advisory Council in Angoon. The group voted to launch a campaign to ask the community to not fish the Kanalku stock until the sockeye salmon runs are rebuilt. The group seeks to get the major fishers of this system to agree to this moratorium.

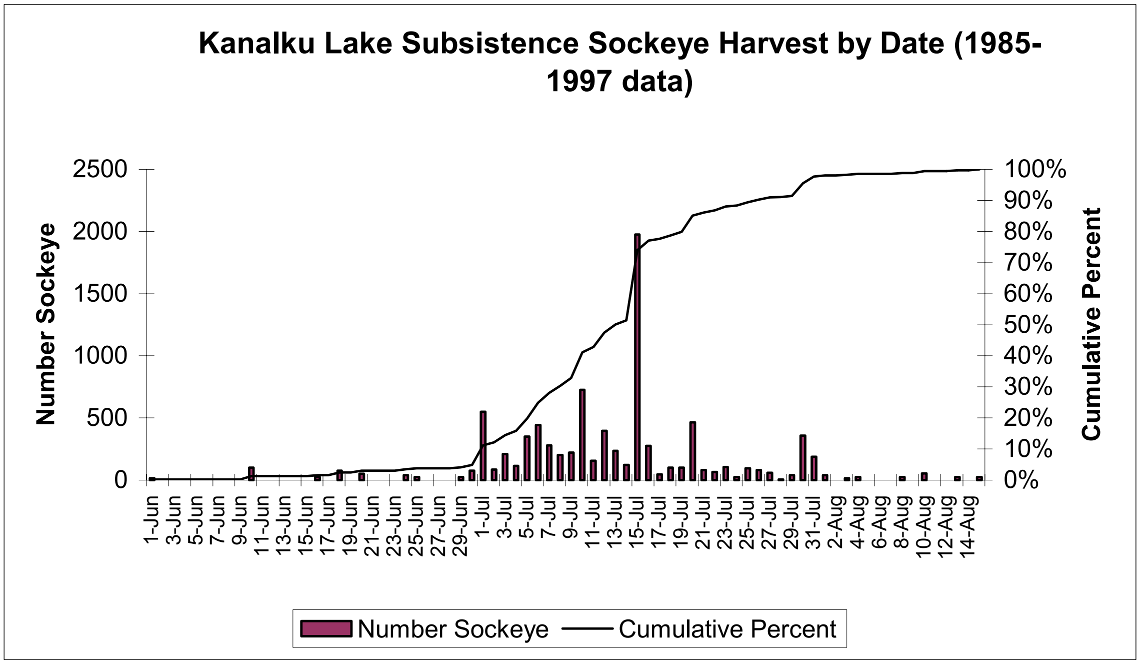

Figure 7. The history of the subsistence fishery harvest by date in Kanalku Bay as reported on the subsistence permits for this area.

The second objective to describe the size and age structure of the sockeye salmon fry and adult populations was met with moderate success. The size and age structure of the sockeye salmon fry and adult population can only be viewed as preliminary because of the low sample sizes.

We successfully collected baseline physical characteristics of the lake and estimates zooplankton biomass densities by species throughout the season. However, results from the 2001 season are preliminary and have little interpretive value without more years for comparison across a wide variety of climatic conditions and fry densities. For example, although the 2001 mean euphotic zone depth (11.06 m) was not as deep as the mean in 1995 (14.6 m), climatic differences in the amount of summer precipitation could alter the amount of tannins coming into the lake.

Sitkoh Lake

In the first year of the project, objectives to estimate adult sockeye escapement, estimate the sockeye salmon fry population, describe the size and age structure of fry and adult sockeye salmon populations, and describe the productivity of Sitkoh Lake were completed. Good sample sizes were obtained in all five mark-recapture events in Sitkoh Lake, and the precision was within the limits specified in the objectives. The number of recaptures between events was large enough that a good multiple mark-recapture estimate could be generated for the index area. The expansion of the index area estimate to an escapement estimate for the whole lake using regression techniques allowed us to estimate whole lake population. However, this lake estimate must be viewed as a very rough estimate. We are making an untested assumption that the spawning sockeye salmon population within the index area is representative of the population of the whole lake (Crabtree 2000, 2001). We know the relationship between visual counts and actual numbers of fish (as estimated by mark-recapture) is not necessarily linear, especially at high densities of fish, where greater undercounting error has been observed (Jones et al. 1998). Even if the escapement estimates are biased, they will still indicate trends in escapement if the mark-recapture methods are used consistently over the years. The escapement estimate for 2001 is within the range of mark-recapture escapement estimates from 1996–2000 (Table 10; Cook 1998; Crabtree 2000, 2001). Our methods were similar to those studies, and we think that these estimates provide a reliable index of escapement.

It appears that the Sitkoh Lake sockeye salmon adult returns are healthy and have remained stable over the past six years (Table 11). This moderately stained lake had moderate sockeye salmon fry densities compared to other sockeye salmon rearing lakes with subsistence harvests in Southeast Alaska (Tables 12 and 13). The populations of cladocerans *Daphnia* spp. and *Bosmina* spp., which are the preferred food of sockeye fry, appear to be healthy. The body sizes of these zooplankters are large enough to be within the preferred size range for sockeye salmon fry. We know very little about competition and predation in Sitkoh Lake however. Although no stickleback were found in trawl samples in 2001, there could be competition or predation or both from other salmonids in this system.

Table 11. Comparison of the 2001 escapement estimate with previous year's estimates for Sitkoh Lake sockeye salmon (note that the location of the index area was the same in all years, but it may have varied in size).

Year	Index Area	Whole Lake
1996	na	16,300
1997	4,488	5,984
1998	na	6,649
1999	8,318	10,499
2000	12,362	17,040
2001	8,787	12,209

Table 12. Seasonal mean euphotic zone depths (EZD) for 12 sockeye salmon rearing lakes in Southeast Alaska that are important to subsistence users.

Lake	EZD (m)
Thoms	3.00
Hoktaheen	3.16
Klawock	4.24
Klag	4.56
Salmon Bay	4.60
Luck	4.60
Kook	5.82
Sitkoh	6.69
Hetta	7.94
Falls	9.71
Gut Bay	10.91
Kanalku	11.06

Table 13. Sockeye salmon fry density estimates (fry·m^{-2}) from hydroacoustic surveys conducted in 2001 for 18 sockeye rearing lakes important to subsistence users in Southeast Alaska.

Lake	Density (fry·m^{-2})
Kanalku	<0.01
Mahoney	<0.01
Redoubt	0.01
Chilkat	0.01
Kook	0.03
Klawock	0.07
Salmon Bay	0.07
Chilkoot	0.09
Falls	0.09
Luck	0.10
Sitkoh	0.14
Klag	0.14
Salmon	0.14
Kutlaku	0.23
Hoktaheen	0.25
Gut	0.32
Thoms	0.89
Hetta	1.20

Hasselborg River

Attempts to conduct a mark-recapture study in the Hasselborg River were not successful. Mark-recapture methods currently used by ADF&G include weirs, beach seining on the spawning grounds, and a combination of beach seines and dipnets in inlet streams. A weir is expensive and requires a full-time crew to maintain it and was not an option for this project. Sockeye salmon in the deep, fast-flowing water of Hasselborg River were not easily catchable by either seine or dipnet. They did not appear to form stable, "closed" spawning sub-populations from which repeatable samples could be taken and which would meet assumptions such as uniform mixing. Since the numbers of sockeye observed on escapement surveys have been relatively high and stable over recent years, there is no particular concern about the Hasselborg River sockeye salmon stock unless harvest effort increases significantly in this system.

CONCLUSIONS

The three systems included in this study, Kanalku, Hasselborg, and Sitkoh, provide the most important subsistence fisheries for the people of Angoon. Results from the first year of the project provided a preliminary assessment of the health of the stocks in Kanalku and Sitkoh Lakes. The community of Angoon is concerned about the poor sockeye salmon adult returns and low fry densities in Kanalku Lake.

The science-based approach merely confirmed their perceptions that this stock is severely depressed. Consequently, community leaders are encouraging subsistence users to shift their efforts to Sitkoh Lake and Salt Lake/Hasselborg River and allow Kanalku Lake stocks to rebuild. Angoon subsistence users have demonstrated flexibility and adaptability to changing resource patterns over time, minimizing harvests in less productive areas and taking advantage of new opportunities where resources are abundant. In an effort to maximize our research under budgetary constraints, the cooperators have decided to discontinue most research at Hasselborg River but add Kook Lake to this tri-lake project in the upcoming season. The on-going monitoring of sockeye salmon stocks in Sitkoh, Kook, and Kanalku lakes will provide information needed to set escapement goals and to evaluate the response of these systems to known escapement levels, so that sockeye salmon production can be sustained for future generations.

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APPENDICES

APPENDIX A. Historical sockeye salmon harvest information from Kanalku Bay and Lake, Hasselborg River/Salt Lake, and Sitkoh Bay and Lake.

Appendix A.1. Subsistence harvest of sockeye salmon reported on permits from Kanalku Bay and Lake, 1985–2000 (ADF&G Alexander database, 2002). Sockeye salmon harvest is reported on returned permits by permit holders; there is no independent validation of these figures.

Year	Number of Permits	Total Sockeye Harvest	Average Sockeye Harvest Per Permit
1985	22	473	22
1986	37	931	25
1987	20	645	32
1988	10	258	26
1989	16	425	27
1990	30	762	25
1991	22	556	25
1992	21	571	27
1993	32	901	28
1994	42	1282	31
1995	39	936	24
1996	59	1627	28
1997	56	1538	27
1998	53	1482	28
1999	57	1666	29
2000	50	1443	29
Average	35	969	27

Appendix A.2. Subsistence harvest of sockeye and coho salmon reported on permits from Hasselborg River/Salt Lake, 1985–2000 (ADF&G Alexander database, 2002). Sockeye salmon harvest is reported on returned permits by permit holders; there is no independent validation of these figures.

Year	Number of Permits	Total Sockeye Harvest	Total Coho Harvest	Average Sockeye Harvest per Permit	Average Coho Harvest per Permit
1985	15	0	260	0	17
1986	14	60	250	4	18
1987	5	45	105	9	21
1988	2	0	12	0	6
1989	5	0	100	0	20
1990	5	25	85	5	17
1991	9	50	115	6	13
1992	7	0	160	0	23
1993	19	25	460	1	24
1994	10	87	160	9	16
1995	13	45	230	3	18
1996	16	78	450	5	28
1997	20	110	389	6	19
1998	18	67	349	4	19
1999	7	60	91	9	13
2000	7	40	122	6	17
Average	11	43	209	4	18

Appendix A.3. Subsistence harvest of sockeye salmon reported on permits from Sitkoh Lake, 1985–2000 (ADF&G Alexander database, 2002). Sockeye harvest is reported on returned permits by permit holders; there is no independent validation of these figures.

Year	Number of Permits	Total Sockeye Harvest	Average Sockeye Harvest per Permit
1985	40	313	8
1986	48	677	14
1987	36	636	18
1988	25	322	13
1989	16	248	16
1990	18	181	10
1991	0	0	-
1992	1	90	90
1993	0	0	-
1994	2	36	18
1995	1	10	10
1996	3	50	17
1997	6	60	10
1998	2	16	8
1999	6	36	6
2000	7	56	8
Average	13	171	17

Appendix A.4. Sport fishing data from Kanalku Lake, Hasselborg River/Salt Lake, and Sitkoh Bay and Lake. In the saltwater area of Sitkoh Bay, 11 to 131 angler days were reported annually from 1988–1999, but zero sockeye salmon were caught or retained. The Division of Sport Fish did not record the number of fish caught and released before 1990 (ADF&G database; Robert Walker, personal communication, 2000).

System/Area	Year	Number of Anglers	Angler Days	Sockeye Caught	Sockeye Kept	Coho Caught	Coho Kept
Kanalku Lake Freshwater Only	1992	12	12	0			
	1993	78	320	241			
Hasselborg R. Salt Lake	1984	72	41		0		0
	1987	36	36		0		0
	1988	62	91		0		0
	1989	70	70		0		0
	1990	34	34	0	0	0	0
	1992	62	64	0	0	8	8
	1993	65	202	48	0	0	0
	1994	13	60	0	0	0	0
	1995	13	14	0	0	0	0
	1996	69	272	455	0	219	0
	1998	106	154	0	0	0	0
	1999	33	76	85	21	0	0
Sitkoh Lake freshwater only	1985	389	486		0		
	1986	622	1,072		0		
	1987	501	642		7		
	1988	340	367		0		
	1989	263	555		0		
	1990	392	694	0	0		
	1991	301	795	0	0		
	1992	187	437	0	0		
	1993	480	1,627	0	0		
	1994	589	1,257	9	0		
	1995	145	360	0	0		
	1996	109	109	0	0		
	1997	212	590	170	0		
	1998	256	401	258	0		
	1999	526	1,304	0	0		

Appendix A.5. Historical commercial sockeye salmon harvest data for Sitkoh Bay.

Year	Commercial Sockeye Harvest
1890	4,902
1895	4,260
1896	15,794
1897	566
1900	30,000
1904	12,000
1918	833
1921	552
1922	3,462
1924	234
1925	248
1926	337
1927	122

APPENDIX B. Escapement and ecological data from the Kanalku, Hasselborg, and Sitkoh systems.

Appendix B.1. Visual sockeye salmon counts from ADF&G aerial surveys over the Kanalku Lake system, 1960–2000 (ADF&G Alexander database, 2002). Some peak counts from the lake outlet are not shown. These surveys estimated an unknown portion of the escapement in each year. The peak counts are simply the highest count recorded in a given season and do not represent total or peak escapement.

Year	Date	Peak Sockeye Count	No. of Surveys	Survey Type	Location
1960	08/08	200	1	AERIAL	outlet
-	-	-	-	-	-
1968	07/07	1,000	1	AERIAL	outlet
-	-	-	-	-	-
1978	08/23	200	1	AERIAL	outlet
-	-	-	-	-	-
1981	09/25	5	1	FOOT	mouth of inlet
-	-	-	-	-	-
1983	09/13	200	1	AERIAL	outlet
1984	09/26	30	1	AERIAL	mouth of inlet
1985	09/11	250	1	AERIAL	outlet
1985	09/18	20	1	AERIAL	mouth of inlet
1986	09/11	1,250	3	AERIAL	outlet
1987	09/02	200	1	AERIAL	mouth of inlet
1987	09/08	300	2	AERIAL	outlet
1988	09/07	300	2	AERIAL	outlet
1989	08/28	200	1	AERIAL	lake
1989	09/14	300	3	AERIAL	outlet
1990	09/12	300	2	AERIAL	lake
1991	09/11	200	2	AERIAL	lake
-	-	-	-	-	-
1993	09/03	720	1	AERIAL	lake
1994	09/01	250	2	AERIAL	lake
-	-	-	-	-	-
1996	09/06	200	2	AERIAL	lake
1997	09/11	200	1	AERIAL	lake
1998	09/09	500	3	AERIAL	lake
1999	09/10	220	3	AERIAL	lake
2000	08/10	1,500	2	AERIAL	outlet
2000	09/03	250	4	AERIAL	lake
2001	08/23	169	4	BOAT	lake

Appendix B.2. Visual sockeye and coho counts from ADF&G surveys at Hasselborg River, 1967–2000 (ADF&G Alexander database, 2002). These surveys estimated an unknown portion of the escapement in each year. The peak counts are simply the highest count recorded in a given season and do not represent total or peak escapement.

Species	Year	Date	Peak Count	Number of Surveys	Survey Type
Coho	1967	09/30	1,300	1	AERIAL
-	-	-	-	-	-
Sockeye	1974	08/28	2	1	AERIAL
-	-	-	-	-	-
Coho	1979	09/18	200	1	AERIAL
-	-	-	-	-	-
Coho	1981	10/16	2,000	5	FOOT
Coho	1982	10/18	208	3	FOOT
Sockeye	1983	09/29	2	1	FOOT
Coho	1983	10/15	1,800	5	AERIAL
Coho	1984	09/26	700	5	AERIAL
Coho	1985	09/11	550	4	AERIAL
Coho	1986	08/26	1,100	6	AERIAL
Sockeye	1987	08/24	50	1	AERIAL
Coho	1987	09/02	1,300	4	AERIAL
Sockeye	1988	08/25	2	1	AERIAL
Coho	1988	09/26	2,300	7	AERIAL
Sockeye	1989	08/25	4,930	6	BOAT
Coho	1989	09/14	600	5	AERIAL
Coho	1990	09/05	2,000	7	AERIAL
Sockeye	1990	09/05	1,000	2	AERIAL
Sockeye	1991	08/01	500	4	AERIAL
Coho	1991	10/16	1,000	5	AERIAL
Sockeye	1992	08/07	300	1	AERIAL
Coho	1992	09/02	1,300	6	AERIAL
Sockeye	1993	09/03	1,000	4	AERIAL
Coho	1993	09/14	2,000	8	AERIAL
Sockeye	1994	09/07	2,365	4	AERIAL
Coho	1994	09/30	7,740	8	HELICOPTER
Sockeye	1995	09/07	7,221	5	FOOT
Coho	1995	09/22	8,370	8	HELICOPTER
Sockeye	1996	09/06	2,400	6	AERIAL
Coho	1996	10/01	2,205	6	HELICOPTER
Coho	1997	10/02	4,050	2	HELICOPTER
Sockeye	1998	08/21	5,500	7	AERIAL
Coho	1998	10/03	4,680	2	HELICOPTER
Sockeye	1999	08/03	2,200	4	AERIAL
Coho	1999	10/04	500	1	AERIAL
Sockeye	2000	08/14	9,000	6	AERIAL
Coho	2000	09/03	3,000	1	AERIAL

Appendix B.3. Sockeye salmon escapement estimates in Sitkoh Lake (Crabtree 2001).

Year	Estimated Escapement	Type of Estimate
1982	7,200	weir count
1996	16,300	mark-recapture
1997	6,000	modified Jolly Seber mark-recapture
1998	6,600	Petersen mark-recapture, 2 points
1999	10,500	modified Jolly Seber mark-recapture
2000	17,000	modified Jolly Seber mark-recapture

Appendix B.4. Age and length composition of Hasselborg River sockeye salmon in 1989 (3–16 September).

		Brood Year and Age Class				
		1986	**1985**	**1985**	**1984**	
		0.2	**0.3**	**1.2**	**1.3**	**Total**
Male	Sample Size	1	80	2	16	99
	Percent in Age Class	0.7	59.3	1.5	11.9	73.3
	Std. Error	0.7	4.2	1	2.8	3.8
	Average Length		557	520	550	555
	Std. Error		2.6	25	7.2	2.5
Female	Sample Size		32	2	2	36
	Percent		23.7	1.5	1.5	26.7
	Std. Error		3.7	1	1	3.8
	Average Length		513	503	520	512
	Std. Error		3.6	12.5	10	3.3
All Fish	Sample Size	1	112	4	18	135
	Percent	0.7	83	3	13.3	100
	Std. Error	0.7	3.2	1.5	2.9	
	Average Length		544	511	547	543
	Std. Error		2.9	12.5	6.8	2.6

Appendix B.5. Age and length compositions of Sitkoh Lake sockeye salmon samples taken in 1982–1984, 1987, and 1996–1999. Mid-eye to fork length was measured in the field, and scales were collected for age analysis, from escapement sampling in Sitkoh Lake.

Age	1982	1983	1984	1987	1996	1997	1998	1999		
	Sample Size									
0.3	0	0	0	0	0	1	0	0		
1.1	0	2	1	6	14	2	21	2		
1.2	186	206	33	178	85	123	168	83		
1.3	548	114	378	287	363	197	208	83		
1.4	1	0	0	1	3	0	0	0		
2.1	0	0	0	2	1	1	4	0		
2.2	10	3	2	16	4	24	5	0		
2.3	19	4	3	5	10	7	4	1		
all	764	329	417	495	480	355	410	169		
	Percent in Age Class								**Mean, all yrs**	**Std. Error**
0.3	0	0	0	0	0	0.3	0	0	0	0
1.1	0	0.6	0.2	1.2	2.9	0.6	5.1	1.2	1.4	0.2
1.2	24.3	62.6	7.9	36	17.7	34.6	41	49.1	31.1	0.8
1.3	71.7	34.7	90.6	58	75.6	55.5	50.7	49.1	63.7	0.8
1.4	0.1	0	0	0.2	0.6	0	0	0	0.1	0.1
2.1	0	0	0	0.4	0.2	0.3	1	0	0.2	0.1
2.2	1.3	0.9	0.5	3.2	0.8	6.8	1.2	0	1.9	0.2
2.3	2.5	1.2	0.7	1	2.1	2	1	0.6	1.6	0.2
	Average Length								**Mean, All Yrs**	**Std. Error**
0.3	0	0	0	0	0	535	0	0	535	0
1.1	0	345	0	356	344	365	352	346	350	2.2
1.2	496	474	490	481	505	503	489	485	489	0.7
1.3	556	533	542	548	560	554	544	541	550	0.5
1.4	600	0	0	550	596	0	0	0	588	12.5
2.1	0	0	0	372	360	380	338	0	354	7.9
2.2	501	498	490	475	515	496	495	0	492	3.1
2.3	558	540	515	552	562	557	547	543	553	3.1
Mean, All Ages	540	495	538	519	544	531	509	511	527	
Std. Error	19.7	27	26.5	23.3	25.3	27.8	25.4	44.4	9.1	

Appendix B.6. Limnology and lake ecology results from sampling at Kanalku Lake in 1995 (Barto and Cook 1996) and Sitkoh Lake in 1992.

Lake and Year	**Lake Type**	**Sockeye Fry Density (no · m^2)**	**Euphotic Zone Depth (m)**	**Spring Total Phosporus (μg · L^{-1})**	**Water Residence Time (yrs)**	**Zooplankton Density (all Species, no · m^2)**	**Zooplankton Species Composition**
Kanalku 1995	stained	0.126	14.6	1.8	0.24	102,427	*Bosmina* sp. *Cyclops* sp.
Sitkoh 1992	stained	na	6.1	4.4	0.64	119,000	*Cyclops vernalis* *Bosmina coregoni* *Daphnia longiremus*

APPENDIX C. Age, sex, and length composition of sockeye salmon sampled in the Kanalku Lake, Sitkoh Lake, and Hasselborg River escapements, 2001.

Appendix C.1. Age, sex, and length data from adult sockeye salmon sampled in Kanalku Lake, 2001.

Date	Sample No.	Sex	Length (mm)	Age	Readability
09/07/01	1	1	475	1.2	
09/07/01	1	1	555	1.3	
09/07/01	2	1	460	1.2	
09/07/01	2	2	560	1.3	
09/07/01	3	1	520		regenerated scale
09/07/01	3	2	480	1.2	
09/07/01	4	2	475	1.2	
09/07/01	4	2	455	1.2	
09/07/01	5	1	480	1.2	
09/07/01	5	2	505	1.2	
09/07/01	6	1	520	1.3	
09/07/01	6	1	535	1.3	
09/07/01	7	1	485	1.2	
09/07/01	7	1	530	1.3	
09/07/01	8	2	480	1.2	
09/07/01	8	1	550	1.3	
09/07/01	9	2	460	1.2	
09/07/01	9	2	490	1.2	
09/07/01	10	2	465	1.2	
09/07/01	10	1	550	1.3	
09/07/01	11	1	540		regenerated scale
09/07/01	11	1	515	1.2	
09/07/01	12	2	540		regenerated scale
09/07/01	12	2	455	1.2	
09/07/01	13	1	555		regenerated scale
09/07/01	14	1	520	1.3	
09/07/01	15	2	485		regenerated scale
09/07/01	16	2	465	1.2	
09/07/01	17	2	525		regenerated scale
09/07/01	18	1	500	1.2	
09/07/01	19	1	540	1.3	
09/07/01	20	1	545	1.3	
09/07/01	21	2	475		regenerated scale
09/07/01	22	1	525		regenerated scale
09/07/01	23	1	545		regenerated scale
09/07/01	24	2	460	1.2	
09/07/01	25	2	465	1.2	
09/07/01	26	1	555		regenerated scale
09/07/01	27	1	550	1.3	
09/07/01	28	1	550	1.3	
09/07/01	29	2	470	1.3	
09/07/01	30	1	540	1.3	
09/07/01	31	2	490	1.2	

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Date	Sample No.	Sex	Length (mm)	Age	Readability
09/07/01	32	1	520	1.3	
09/07/01	33	1	545	1.3	
09/07/01	34	1	520	1.3	
09/07/01	35	1	420	1.2	
09/07/01	36	1	465	2.2	
09/07/01	37	1	550		regenerated scale
09/07/01	38	2	470	1.2	
09/07/01	39	2	525	1.3	
09/07/01	40	1	545		regenerated scale
09/08/01	1	2	465	1.2	
09/08/01	2	2	440		regenerated scale
09/08/01	3	1	530	1.3	
09/08/01	4	2	530	1.3	
09/08/01	5	2	480		regenerated scale
09/08/01	6	1	530		regenerated scale
09/08/01	7	2	565	1.3	
09/08/01	8	1	485	1.2	
09/08/01	9	1	525		regenerated scale
09/08/01	10	1	570	1.3	
09/08/01	11	1	465	1.2	
09/08/01	12	2	490	1.2	
09/08/01	13	2	455	1.2	
09/08/01	14	1	500	1.2	
09/08/01	15	2	560	1.3	
09/08/01	16	1	555		regenerated scale
09/08/01	17	1	525	1.3	
09/08/01	18	2	475		regenerated scale
09/08/01	19	2	470	1.2	
09/08/01	20	1	535		regenerated scale
09/08/01	21	2	515		regenerated scale
09/08/01	22	1	555	1.3	
09/08/01	23	1	535	1.3	
09/08/01	24	2	480	1.3	
09/08/01	25	1	520	1.3	
09/08/01	26	1	555	1.3	
09/08/01	27	2	465	1.2	
09/08/01	28	1	585		regenerated scale
09/08/01	29	2	530		regenerated scale
09/08/01	30	1	545	1.3	
09/08/01	31	2	515		regenerated scale
09/08/01	32	2	480	1.2	
09/08/01	33	2	520		regenerated scale
09/08/01	34	1	530	1.3	
09/08/01	35	1	500		regenerated scale
09/08/01	36	1	525	1.3	
09/08/01	37	2	470	1.2	

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Date	Sample No.	Sex	Length (mm)	Age	Readability
09/20/01	1	2	500	1.2	
09/20/01	2	2	500	1.2	
09/20/01	3	2	485	1.2	
09/20/01	4	2	450	1.2	
09/20/01	5	2	450	1.2	
09/20/01	6	2	485	1.2	
09/20/01	7	2	460	1.2	
09/20/01	8	2	455		regenerated scale
09/20/01	9	1	560	1.3	
09/20/01	10	2	480		regenerated scale
09/20/01	11	1	510	1.2	
09/20/01	12	1	530	1.3	
09/20/01	13	2	470	1.2	
09/20/01	14	2	465	1.2	
09/20/01	15	1	535	1.3	
09/20/01	16	1	490	1.2	
09/20/01	17	2	460	1.2	
09/20/01	18	1	510		regenerated scale
09/20/01	19	2	460	1.2	
09/20/01	20	2	490	1.2	
09/20/01	21	2	510		regenerated scale
09/21/01	1	2	460	1.2	
09/21/01	2	2	480	1.2	
09/21/01	3	2	560	1.3	
09/21/01	4	2	550	1.3	
09/21/01	5	1	490	2.2	
09/21/01	6	1	540		regenerated scale
09/21/01	7	2	460	1.2	
09/21/01	8	2	480		regenerated scale
09/21/01	9	2	480		regenerated scale
09/21/01	10	2	550	1.3	
09/21/01	11	2	540	1.3	

Appendix C.2. Age, sex, and length data from adult sockeye salmon sampled in Hasselborg River, 2001.

Date	Sample No.	Sex	Length (mm)	Age	Readability
09/23/01	1	2	535	1.3	
09/23/01	2	1	670		regenerated scale
09/23/01	3	2	550		regenerated scale
09/23/01	4	2	550	1.3	
09/23/01	5	2	535		regenerated scale
09/23/01	6	2	545		regenerated scale
09/23/01	7	2	570	1.3	
09/23/01	8	2	525	1.3	
09/23/01	9	2	530		regenerated scale
09/23/01	10	2	560	1.3	
09/23/01	11	2	540	1.3	
09/23/01	12	2	550	1.3	
09/23/01	13	2	549		regenerated scale
09/23/01	14	1	585		regenerated scale
09/23/01	15	2	540		regenerated scale
09/24/01	1	1	565		regenerated scale
09/24/01	2	1	610		regenerated scale
09/24/01	3	1	530	1.2	
09/24/01	4	1	560		regenerated scale
09/24/01	5	1	515		regenerated scale
09/24/01	6	1	650		regenerated scale
09/24/01	7	1	640		regenerated scale
09/24/01	8	2	520		regenerated scale
09/24/01	9	2	530		regenerated scale
09/24/01	10	2	540		regenerated scale
09/24/01	11	2	530		regenerated scale
09/24/01	12	1	570		regenerated scale
09/24/01	13	1	600		regenerated scale
09/24/01	14	2	555		regenerated scale
09/24/01	15	2	530		regenerated scale
09/24/01	16	2	540		regenerated scale
09/24/01	17	2	510		regenerated scale
09/24/01	18	2	540		regenerated scale
09/24/01	19	2	550		regenerated scale
09/24/01	20	2	550		regenerated scale
09/24/01	21	2	490		regenerated scale
09/24/01	22	2	510	1.3	
09/24/01	23	2	520	1.3	
09/24/01	24	2	540	1.3	
09/24/01	25	2	540	1.3	
09/24/01	26	2	530		regenerated scale
09/24/01	27	2	510	1.3	
09/24/01	28	2	530		regenerated scale
09/24/01	29	2	530	1.3	

Appendix C.3. Age, sex, and length data from adult sockeye salmon sampled in Sitkoh Lake, 2001.

Date	Sample No.	Sex	Length (mm)	Age	Readability
08/29/01	1	1	575	1.3	
08/29/01	1	1	560	1.3	
08/29/01	1	2	545	1.3	
08/29/01	1	2	560	1.3	
08/29/01	1	1	550		regenerated scale
08/29/01	2	1	580	1.3	
08/29/01	2	1	570	1.3	
08/29/01	2	1	600	1.3	
08/29/01	2	2	565	1.3	
08/29/01	2	1	540		regenerated scale
08/29/01	3	1	570	1.3	
08/29/01	3	1	540	1.3	
08/29/01	3	1	525	1.3	
08/29/01	3	2	570	1.3	
08/29/01	3	2	555		regenerated scale
08/29/01	4	1	550	1.3	
08/29/01	4	2	520	1.3	
08/29/01	4	2	555	1.3	
08/29/01	4	2	550	1.3	
08/29/01	4	1	600		regenerated scale
08/29/01	5	1	530	1.3	
08/29/01	5	1	580	1.3	
08/29/01	5	2	560	1.3	
08/29/01	5	1	540		regenerated scale
08/29/01	5	1	570		regenerated scale
08/29/01	6	1	605	1.3	
08/29/01	6	1	560	1.3	
08/29/01	6	2	530	1.3	
08/29/01	6	2	560	1.3	
08/29/01	6	1	560		regenerated scale
08/29/01	7	1	520	1.3	
08/29/01	7	1	540	1.3	
08/29/01	7	2	590	1.3	
08/29/01	7	2	530	1.3	
08/29/01	7	2	560	1.3	
08/29/01	8	1	550	1.3	
08/29/01	8	1	590	1.3	
08/29/01	8	1	590	1.3	
08/29/01	8	1	535	1.3	
08/29/01	8	1	560		regenerated scale
08/29/01	9	2	490	1.2	
08/29/01	9	1	570	1.3	
08/29/01	9	1	560	1.3	
08/29/01	9	1	550	1.3	
08/29/01	9	2	520	1.3	
08/29/01	10	1	555	1.3	
08/29/01	10	1		1.3	

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Date	Sample No.	Sex	Length (mm)	Age	Readability
08/29/01	10	2	530	1.3	
08/29/01	10	2	550	1.3	
08/29/01	11	1	575	1.3	
08/29/01	11	1	560	1.3	
08/29/01	11	2	560	1.3	
08/29/01	11	2	535	1.3	
08/29/01	11	2	480	1.3	
08/29/01	12	1	600	1.3	
08/29/01	12	1	535	1.3	
08/29/01	12	1	550	1.3	
08/29/01	12	1	575	1.3	
08/29/01	12	2	550	1.3	
08/29/01	13	1	550	1.3	
08/29/01	13	2	590	1.3	
08/29/01	13	2	540	1.3	
08/29/01	13	2	525	1.3	
08/29/01	13	2	550	1.3	
08/29/01	14	1	480	1.2	
08/29/01	14	1	580	1.3	
08/29/01	14	2	560	1.3	
08/29/01	14	2	560	1.3	
08/29/01	14	2	515	1.3	
08/29/01	15	1	500	1.2	
08/29/01	15	1	550	1.3	
08/29/01	15	1	580	1.3	
08/29/01	15	2	565	1.3	
08/29/01	15	2	550	1.3	
08/29/01	16	1	575	1.3	
08/29/01	16	1	575	1.3	
08/29/01	16	2	570	1.3	
08/29/01	16	2	510	1.3	
08/29/01	16	1	565		regenerated scale
08/29/01	17	1	570	0.3	
08/29/01	17	1	600	1.3	
08/29/01	17	1	550	1.3	
08/29/01	17	1	555	1.3	
08/29/01	17	2	570	1.3	
08/29/01	18	1	570	1.3	
08/29/01	18	1	580	1.3	
08/29/01	18	1	550	1.3	
08/29/01	18	2	570	1.3	
08/29/01	18	2	545	1.3	
08/29/01	19	1	540	1.3	
08/29/01	19	1	560	1.3	
08/29/01	19	1	550	1.3	
08/29/01	19	2	560	1.3	
08/29/01	19	2	575	1.3	

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Date	Sample No.	Sex	Length (mm)	Age	Readability
08/29/01	20	1	580	1.3	
08/29/01	20	1	560	1.3	
08/29/01	20	2	540	1.3	
08/29/01	20	2	560	1.3	
08/29/01	20	2	575		regenerated scale
08/29/01	21	1	550	1.3	
08/29/01	21	1	560	1.3	
08/29/01	21	2	580	1.3	
08/29/01	21	2	555	1.3	
08/29/01	21	1	510		regenerated scale
08/29/01	22	1	580	1.3	
08/29/01	22	2	525	1.3	
08/29/01	22	2	535	1.3	
08/29/01	22	2	550		regenerated scale
08/29/01	22	2	530		regenerated scale
08/29/01	23	1	550	1.3	
08/29/01	23	2	570	1.3	
08/29/01	23	2	580	1.3	
08/29/01	23	2	530	1.3	
08/29/01	23	1	540		regenerated scale
08/29/01	24	1	455	1.2	
08/29/01	24	1	560	1.3	
08/29/01	24	1	565	1.3	
08/29/01	24	2	530	1.3	
08/29/01	24	2	575		regenerated scale
08/29/01	25	1	545	1.3	
08/29/01	25	1	560	1.3	
08/29/01	25	1	550	1.3	
08/29/01	25	1	560	1.3	
08/29/01	25	1	535	1.3	
08/29/01	26	1	565	1.3	
08/29/01	26	1	545	1.3	
08/29/01	26	1	550	1.3	
08/29/01	26	2	575	1.3	
08/29/01	26	2	550		regenerated scale
08/29/01	27	1	560	1.3	
08/29/01	27	1	570	1.3	
08/29/01	27	2	540	1.3	
08/29/01	27	2	580	1.3	
08/29/01	27	2	525	1.3	
08/29/01	28	1	560	1.3	
08/29/01	28	1	550	1.3	
08/29/01	28	2	560	1.3	
08/29/01	28	1	545		regenerated scale
08/29/01	28	1	580		regenerated scale
08/29/01	29	1	580	1.3	
08/29/01	29	1	580	1.3	

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Date	Sample No.	Sex	Length (mm)	Age	Readability
08/29/01	29	2	540	1.3	
08/29/01	29	1	560		regenerated scale
08/29/01	29	1	570		regenerated scale
08/29/01	30	1	540	1.3	
08/29/01	30	1	550	1.3	
08/29/01	30	2	570	1.3	
08/29/01	30	2	550	1.3	
08/29/01	30	1	565		regenerated scale
08/29/01	31	1	545	1.3	
08/29/01	31	1	580	1.3	
08/29/01	31	1	535	1.3	
08/29/01	31	2	530	1.3	
08/29/01	31	1	590		regenerated scale
08/29/01	32	1	580	1.3	
08/29/01	32	1	570	1.3	
08/29/01	32	1	540	1.3	
08/29/01	32	2	565	1.3	
08/29/01	32	2	545	1.3	
08/29/01	33	1	575	1.3	
08/29/01	33	1	580	1.3	
08/29/01	33	1	560	1.3	
08/29/01	33	2	550	1.3	
08/29/01	33	2	540	1.3	
08/29/01	34	1	545	1.3	
08/29/01	34	1	580	1.3	
08/29/01	34	2	510	1.3	
08/29/01	34	2	530	1.3	
08/29/01	34	2	560		regenerated scale
08/29/01	35	1	575	1.3	
08/29/01	35	1	580	1.3	
08/29/01	35	2	545	1.3	
08/29/01	35	2	560	1.3	
08/29/01	35	2	540		regenerated scale
08/29/01	36	2	495	1.2	
08/29/01	36	1	600	1.3	
08/29/01	36	1	535	1.3	
08/29/01	36	1	555	1.3	
08/29/01	36	1	600	1.3	
08/29/01	37	1	540	1.3	
08/29/01	37	1	560	1.3	
08/29/01	37	1	365	1.3	
08/29/01	37	2	515	1.3	
08/29/01	37	1	540		regenerated scale
08/29/01	38	2	550	1.3	
08/29/01	38	2	560	1.3	
08/29/01	38	2	555	1.3	
08/29/01	38	1	540		regenerated scale

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Date	Sample No.	Sex	Length (mm)	Age	Readability
08/29/01	38	2	520		regenerated scale
08/29/01	39	1	515	1.3	
08/29/01	39	2	525	1.3	
08/29/01	39	2	580	1.3	
08/29/01	39	1	540		regenerated scale
08/29/01	39	2	535		regenerated scale
08/29/01	40	1	545	1.3	
08/29/01	40	1	580	1.3	
08/29/01	40	2	560	1.3	
08/29/01	40	2	560		regenerated scale
08/29/01	40	2	535		regenerated scale
08/30/01	1	2	540	1.3	
08/30/01	1	1	555		regenerated scale
08/30/01	2	1	540	1.3	
08/30/01	2	2	580	1.3	
08/30/01	3	1	550		regenerated scale
08/30/01	3	1	540		regenerated scale
08/30/01	4	1	540	1.3	
08/30/01	4	1	555	1.3	
08/30/01	5	2	500	1.2	
08/30/01	5	2	535		regenerated scale
08/30/01	6	1	570		regenerated scale
08/30/01	7	1	550		regenerated scale
08/30/01	8	1	530	1.3	
08/30/01	9	2	545		regenerated scale
08/30/01	10	2	540	1.3	
08/30/01	11	1	550	1.3	
08/30/01	12	2	540		regenerated scale
08/30/01	13	2	560		regenerated scale
08/30/01	14	2	545	1.3	
08/30/01	15	2	515	1.3	
08/30/01	16	1	590	1.3	
08/30/01	17	2	475	1.2	
08/30/01	18	1	570	1.3	
08/30/01	19	2	565		regenerated scale
08/30/01	20	2	535	1.3	
09/09/01	1	1	555	1.3	
09/09/01	1	2	550	1.3	
09/09/01	2	1	560	1.3	
09/09/01	2	1	585	1.3	
09/09/01	3	2	525	1.3	
09/09/01	3	2	520	1.3	
09/09/01	4	1	590	1.3	
09/09/01	4	2	540		regenerated scale
09/09/01	5	1	575	1.3	
09/09/01	5	2	520	1.3	
09/09/01	6	1	470	1.2	

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Date	Sample No.	Sex	Length (mm)	Age	Readability
09/09/01	6	1	530	1.3	
09/09/01	7	1	580	1.3	
09/09/01	7	2	530	1.3	
09/09/01	8	1	480	1.2	
09/09/01	8	1	540	1.3	
09/09/01	9	1	550	1.3	
09/09/01	9	2	540	1.3	
09/09/01	10	1	590	1.3	
09/09/01	10	2	550	1.3	
09/09/01	11	1	530	1.3	
09/09/01	11	2	545	1.3	
09/09/01	12	1	560	1.3	
09/09/01	12	1	550	1.3	
09/09/01	13	2	515	1.3	
09/09/01	13	2	540	1.3	
09/09/01	14	2	530	1.3	
09/09/01	14	2	570		regenerated scale
09/09/01	15	1	555	1.3	
09/09/01	15	2	560		regenerated scale
09/09/01	16	2	570	1.3	
09/09/01	16	2	510	1.3	
09/09/01	17	1	540	1.3	
09/09/01	17	2	550	1.3	
09/09/01	18	1	510	1.3	
09/09/01	18	2	550	1.3	
09/09/01	19	1	550	1.3	
09/09/01	19	1	560	1.3	
09/09/01	20	1	525	1.3	
09/09/01	20	1	555		regenerated scale
09/09/01	21	1	575	1.3	
09/09/01	21	1	560		regenerated scale
09/09/01	22	2	510	1.3	
09/09/01	22	2	535	1.3	
09/09/01	23	2	540	1.3	
09/09/01	23	2	540		regenerated scale
09/09/01	24	2	550	1.3	
09/09/01	24	2	545	1.3	
09/09/01	25	2	550	1.3	
09/09/01	25	2	530	1.3	
09/09/01	26	1	530	1.3	
09/09/01	26	2	515		regenerated scale
09/09/01	27	2	545	1.3	
09/09/01	27	1	540		regenerated scale
09/09/01	28	2	480	1.2	
09/09/01	28	1	580	1.3	
09/09/01	29	1	510	1.3	
09/09/01	29	2	570	1.3	

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Date	Sample No.	Sex	Length (mm)	Age	Readability
09/09/01	30	2	535	1.3	
09/09/01	31	2	545	1.3	
09/09/01	32	1	580	1.3	
09/09/01	33	1	575	1.3	
09/09/01	34	1	590	1.3	
09/09/01	35	1	550	1.3	
09/09/01	36	2	580		regenerated scale
09/09/01	37	2	540	1.3	
09/09/01	38	1	580	1.3	
09/09/01	39	1	570	1.3	
09/09/01	40	2	535	1.3	
09/10/01	1	1	490	1.2	
09/10/01	1	1	520	1.3	
09/10/01	1	2	530	1.3	
09/10/01	2	2	480	1.2	
09/10/01	2	2	530	1.3	
09/10/01	2	2	480		regenerated scale
09/10/01	3	1	530	1.3	
09/10/01	3	1	550	1.3	
09/10/01	3	1	555		regenerated scale
09/10/01	4	1	575	1.3	
09/10/01	4	1	515	1.3	
09/10/01	4	2	570	1.3	
09/10/01	5	1	535	1.3	
09/10/01	5	1	530	1.3	
09/10/01	5	1	580	1.3	
09/10/01	6	1	570	1.3	
09/10/01	6	2	570	1.3	
09/10/01	6	2	560	1.3	
09/10/01	7	2	520	1.3	
09/10/01	7	2	540	1.3	
09/10/01	7	2	560	1.3	
09/10/01	8	1	545	1.3	
09/10/01	8	2	560	1.3	
09/10/01	8	2	560		regenerated scale
09/10/01	9	1	580	1.3	
09/10/01	9	2	545	1.3	
09/10/01	9	2	550	1.3	
09/10/01	10	1	565	1.3	
09/10/01	10	1	570	1.3	
09/10/01	10	2	530	1.3	
09/10/01	11	2	540	1.3	
09/10/01	11	2	570	1.3	
09/10/01	12	2	540	1.3	
09/10/01	12	1	560		regenerated scale
09/10/01	13	1	500	1.2	
09/10/01	13	2	570		regenerated scale

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Appendix C.3. (page 8 of 11)

Date	Sample No.	Sex	Length (mm)	Age	Readability
09/10/01	14	1	560	1.3	
09/10/01	14	1	545	1.3	
09/10/01	15	1	570	1.3	
09/10/01	15	2	570	1.3	
09/10/01	16	1	560		regenerated scale
09/10/01	16	2	560		regenerated scale
09/10/01	17	1	520	1.3	
09/10/01	17	1	590	1.3	
09/10/01	18	2	545	1.3	
09/10/01	18	2	540	1.3	
09/10/01	19	1	570	1.3	
09/10/01	19	2	550	1.3	
09/10/01	20	2	490	1.2	
09/10/01	20	1	540	1.3	
09/10/01	21	1	590	1.3	
09/10/01	21	2	535	1.3	
09/10/01	22	1	570	1.3	
09/10/01	22	2	495	1.3	
09/10/01	23	1	580		regenerated scale
09/10/01	23	2	560		regenerated scale
09/10/01	24	1	480	1.2	
09/10/01	24	2	575	1.3	
09/10/01	25	2	535	1.3	
09/10/01	25	2	545	1.3	
09/10/01	26	1	590	1.3	
09/10/01	26	2	550	1.3	
09/10/01	27	1	535	1.3	
09/10/01	27	1	570	1.3	
09/10/01	28	1	555	1.3	
09/10/01	28	1	560	1.3	
09/10/01	29	1	570	1.3	
09/10/01	29	2	540	1.3	
09/10/01	30	1	575	1.3	
09/10/01	30	2	550	1.3	
09/10/01	31	1	580	1.3	
09/10/01	31	1	590	1.3	
09/10/01	32	1	565	1.3	
09/10/01	32	2	560	1.3	
09/10/01	33		555	1.3	
09/10/01	33	1	570		regenerated scale
09/10/01	34	1	545	1.3	
09/10/01	34	1	555		regenerated scale
09/10/01	35	2	580	1.3	
09/10/01	35	1	535		regenerated scale
09/10/01	36	1	480	1.2	
09/10/01	36	2	525	1.3	
09/10/01	37	2	520	1.3	

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Date	Sample No.	Sex	Length (mm)	Age	Readability
09/10/01	37	2	525	1.3	
09/10/01	38	1	600	1.3	
09/10/01	38	2	530	1.3	
09/10/01	39	1	560	1.3	
09/10/01	39	1	540	1.3	
09/10/01	40	1	520	1.3	
09/10/01	40	2	530	1.3	
09/26/01	1	1	550	1.3	
09/26/01	2	1	540	1.3	
09/26/01	3	2	555	1.3	
09/26/01	4	2	540	1.3	
09/26/01	5	1	370	1.1	
09/26/01	6	1	575		regenerated scale
09/26/01	7	1	480	1.2	
09/26/01	8	2	550	1.3	
09/26/01	9	2	515		regenerated scale
09/26/01	10	1	320	1.1	
09/26/01	11	2	540	1.3	
09/26/01	12	1	490		regenerated scale
09/26/01	13	1	560	1.3	
09/26/01	14	1	560	1.3	
09/26/01	15	2	560	1.3	
09/26/01	16	2	540	1.3	
09/26/01	17	1	570	1.3	
09/26/01	18	1	580		regenerated scale
09/26/01	19	2	560	1.3	
09/26/01	20	2	540	1.3	
09/26/01	21	1	575	1.3	
09/26/01	22	2	540		regenerated scale
09/26/01	23	1	535	1.3	
09/26/01	24	1	590	1.3	
09/26/01	25	1	550	1.3	
09/26/01	26	1	610		regenerated scale
09/26/01	27	2	555	1.3	
09/26/01	28	1	510	1.3	
09/26/01	29	2	530	1.3	
09/26/01	30	1	560		regenerated scale
09/26/01	31	1	350	1.1	
09/26/01	32	1	530		regenerated scale
09/26/01	33	1	550	1.3	
09/26/01	34	1	485	1.2	
09/26/01	35	1	515	1.2	
09/26/01	36	1	570	1.3	
09/26/01	37	1	520		regenerated scale
09/26/01	38	1	545	1.3	
09/26/01	39	2	550	1.3	
09/26/01	40	1	540	1.3	

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Date	Sample No.	Sex	Length (mm)	Age	Readability
09/27/01	1	1	350	1.1	
09/27/01	2	1	450	1.2	
09/27/01	3	2	555	1.3	
09/27/01	4	1	560	1.3	
09/27/01	5	2	535		regenerated scale
09/27/01	6	2	540	1.3	
09/27/01	7	2	555	1.3	
09/27/01	8	2	530		regenerated scale
09/27/01	9	1	575		regenerated scale
09/27/01	10	1	490		regenerated scale
09/27/01	11	1	580	1.3	
09/27/01	12	1	520	1.3	
09/27/01	13	1	590	2.3	
09/27/01	14	1	570	1.3	
09/27/01	15	2	580	1.3	
09/27/01	16	1	570	1.3	
09/27/01	17	1	570	1.3	
09/27/01	18	1	550	1.3	
09/27/01	19	2	560	1.3	
09/27/01	20	2	570	1.3	
10/10/01	1	1	600	1.3	
10/10/01	1	2	560	1.3	
10/10/01	2	1	540	1.3	
10/10/01	2	2	560	1.3	
10/10/01	3	1	580	1.3	
10/10/01	3	2	560		regenerated scale
10/10/01	4	1	365	1.1	
10/10/01	4	1	560	1.3	
10/10/01	5	1	470	1.2	
10/10/01	5	2	560	1.3	
10/10/01	6	1	575	1.3	
10/10/01	6	1	555		regenerated scale
10/10/01	7	1	580	1.3	
10/10/01	7	2	550	1.3	
10/10/01	8	1	570	1.3	
10/10/01	8	2	540	1.3	
10/10/01	9	1	555	1.3	
10/10/01	9	2	500	1.3	
10/10/01	10	1	590	1.3	
10/10/01	10	1	570		regenerated scale
10/10/01	11	2	520		regenerated scale
10/10/01	12	2	560	1.3	
10/10/01	13	1	565	2.3	
10/10/01	14	1	590	1.3	
10/10/01	15	1	580	1.3	
10/10/01	16	1	580		regenerated scale
10/10/01	17	2	550	1.3	

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Date	Sample No.	Sex	Length (mm)	Age	Readability
10/10/01	18	2	570	1.3	
10/10/01	19	1	535	1.3	
10/10/01	20	1	600	1.3	
10/10/01	21	1	550	1.3	
10/10/01	22	1	545	1.3	
10/10/01	23	2	570	1.3	
10/10/01	24	2	550	1.3	
10/10/01	25	2	550	1.3	
10/10/01	26	2	530	1.3	
10/10/01	27	1	600		regenerated scale
10/10/01	28	2	555	1.3	
10/10/01	29	2	550	2.3	
10/10/01	30	1	550		regenerated scale
10/10/01	31	2	490	1.2	
10/10/01	32	2	545	1.3	
10/10/01	33	1	580	1.3	
10/10/01	34	2	570	1.3	
10/10/01	35	1	515	1.3	
10/10/01	36	1	590	1.3	
10/10/01	37	1	540	1.3	
10/10/01	38	2	550	1.3	
10/10/01	39	1	560	1.3	
10/10/01	40	1	560	1.3	

APPENDIX D. Limnology and lake ecology data from 2001.

Appendix D.1. Vertical temperature and dissolved oxygen (DO) profiles for Kanalku Lake in July, August, and October 2001. Dissolved oxygen levels are shown as percent saturation at the indicated temperature. The first measurement at 0.1 m was taken just below the lake surface. High DO values in August may have resulted from equipment error.

	5 Jul.		25 Aug.		19 Oct.	
Depth (m)	**Temp (oC)**	**DO (%)**	**Temp (oC)**	**DO (%)**	**Temp (oC)**	**DO (%)**
0.1						
1.0	11.5	91.3			7.5	92.7
2.0	11.5	92.2	14.5	114.0	7.5	92.7
3.0	11.3	92.5	14.4	115.0	7.5	92.6
4.0	10.8	93.5	14.4	117.0	7.5	92.6
5.0	9.8	93.5	14.0	120.0	7.5	92.7
6.0	9.6	93.4	13.4	119.0	7.5	92.6
7.0	9.2	93.1	13.1	122.0	7.5	92.6
8.0	8.8	92.8	12.5	134.0	7.5	92.6
9.0	8.3	92.0	10.9	133.0	7.5	92.8
10.0	7.9	90.9	10.3	143.0	7.5	92.8
11.0	7.5	89.4	9.6	133.0	7.5	93.0
12.0	7.2	87.9	9.1	132.0	7.5	92.9
13.0	7.0	86.9	8.9	129.0	7.5	93.3
14.0	6.8	86.7	8.2	124.0	7.4	92.8
15.0	6.7	86.5	8.0	125.0	7.4	92.9
16.0	6.6	86.0			7.3	93.0
17.0	6.5	84.9			7.3	93.2
18.0	6.4	84.1			7.3	93.1
19.0	6.3	82.7			7.2	93.1
20.0	6.2	78.9	7.7	123.0	7.1	92.8
25.0	6.1	77.8				

Appendix D.2. Vertical temperature and dissolved oxygen (DO) profiles for Sitkoh Lake in July, September, and October 2001. Dissolved oxygen levels are shown as percent saturation at the indicated temperature. No DO measurements are available for 3 September. The first measurement at 0.1 m was taken just below the lake surface.

Depth (m)	7 Jul. Temp (oC)	DO (%)	3 Sept. Temp (oC)	DO (%)	17 Oct. Temp (oC)	DO (%)
0.1	14.7	100.7				
1.0	14.7	100.0			8.6	88.1
2.0	14.6	97.0	14.4		8.6	88.4
3.0	14.6	96.9	14.3		8.6	86.9
4.0	14.6	96.6	14.3		8.6	85.1
5.0	14.7	97.0	14.3		8.6	83.8
6.0	14.7	96.7	14.3		8.6	83.8
7.0	14.6	98.6	14.3		8.6	83.9
8.0	14.2	98.4	14.3		8.6	83.9
9.0	13.2	98.9	14.0		8.6	84.2
10.0	12.3	97.3	13.8		8.6	83.5
11.0	10.7	97.5	13.6		8.5	83.1
12.0	9.6	97.1	13.1		8.5	83.3
13.0	8.7	96.0	12.8		8.5	83.4
14.0	7.9	97.7	11.1		8.5	83.3
15.0	7.7	97.0	9.5		8.5	83.5
16.0	7.1	96.8	8.2		8.5	83.5
17.0	6.9	98.2	7.6		8.4	83.4
18.0	6.4	98.6	7.1		8.4	83.1
19.0	6.3	98.6	6.7		8.2	82.0
20.0	6.1	98.2	6.5		8.2	83.2
25.0	5.9	96.3	6.3		6.1	71.7
30.0	5.7	80.6	5.9		5.7	70.0
35.0	5.7	88.0	5.8		5.6	65.9

Appendix D.3. Zooplankton density (no·m^{-2}) in Kanalku Lake, 2001.

	Macrozooplankton Density (no·m^{-2})				Seasonal mean (no·m^{-2})
	24-May	**25-Jul**	**25-Aug**	**19-Oct**	
Station A					
Ergasilus					0
Epischura	849	306	10,019	2,547	3,430
Diaptomus	4,160	1,121	4,924	679	2,721
Ovig. Diaptomus		204	170		94
Cyclops	30,396	9,781	9,849	124,639	43,666
Ovig. Cyclops	11,802	4,177	849		4,207
Bosmina	13,075	72,848	43,980	36,509	41,603
Ovig. Bosmina	170	102	170	11,377	2,955
Daphnia l.	7,047	13,347	40,245	21,905	20,636
Ovig. Daphnia l.	509	2,343	9,000	8,151	5,001
Daphnia g.					0
Holopedium	425	306	509		310
Ovig. Holopedium	170	102	0		68
Chydorinae					0
Sida crystalina		0			0
Copepod nauplii	3,481	2,038	17,151	16,811	9,870
Total					**134,561**
Station B					
Ergasilus					0
Epischura	1,698	0	7,336	1,698	2,683
Diaptomus	2,649	5,094	3,124	170	2,759
Ovig. Diaptomus		3,057	136		798
Cyclops	18,203	10,019	4,347	123,111	38,920
Ovig. Cyclops	3,260	5,094	0		2,089
Bosmina	15,147	84,564	54,067	19,019	43,199
Ovig. Bosmina	408	509	136	3,566	1,155
Daphnia l.	2,853	44,150	36,543	18,509	25,514
Ovig. Daphnia l.	68	7,472	3,940	2,887	3,592
Daphnia g.					0
Holopedium	204	2,377	272		713
Ovig. Holopedium	0	0			0
Chydorinae					0
Sida crystalina		0	0		0
Copepod nauplii	3,872	2,717	7,472	25,641	9,926
Total					**131,347**

Appendix D.4. Zooplankton size and biomass in Kanalku Lake, 2001.

	Body Size (mm)				Seasonal Means			
	24 May	25 Jul	25 Aug	19 Oct	Mean length (mm)	Weighted length (mm)	Biomass ($mg \cdot m^{-2}$)	Weighted biomass ($mg \cdot m^{-2}$)
Station A								
Ergasilus								
Epischura	0.89	1.75	1.45	1.49	1.40	1.43	40	43
Diaptomus	0.83	1.24	1.15	1.16	1.10	1.04	15	13
Ovig. Diaptomus		1.29	1.33		1.31	1.31	1	1
Cyclops	1.04	1.14	0.95	0.58	0.93	0.71	134	76
Ovig. Cyclops	1.17	1.16	1.13		1.15	1.17	21	21
Bosmina	0.46	0.50	0.55	0.60	0.53	0.53	110	112
Ovig. Bosmina	0.70	0.61	0.59	0.63	0.63	0.63	11	11
Daphnia l.	0.83	0.93	1.04	0.87	0.92	0.96	79	87
Ovig. Daphnia l.	1.09	1.27	1.13	1.06	1.14	1.12	30	29
Holopedium	0.78	0.90	1.09		0.92	0.94	3	3
Ovig. Holopedium	1.00	1.05	1.09		1.05	1.02	1	1
Sida crystalina		2.62			2.62	2.62	0	0
					Total		**445**	**397**
Station B								
Ergasilus								
Epischura	1.28	1.78	1.09	1.47	1.41	1.18	32	19
Diaptomus	0.88	1.30	1.20	1.15	1.13	1.17	17	18
Ovig. Diaptomus		1.32	1.32		1.32	1.32	8	8
Cyclops	1.05	1.12	0.91	0.49	0.89	0.61	110	48
Ovig. Cyclops	1.15	1.17	1.06		1.13	1.16	10	10
Bosmina	0.50	0.51	0.51	0.59	0.53	0.52	114	110
Ovig. Bosmina	0.65	0.72	0.63	0.65	0.66	0.66	5	5
Daphnia l.	0.86	0.87	0.97	0.98	0.92	0.93	98	99
Ovig. Daphnia l.	1.08	1.25	1.09	1.06	1.12	1.17	21	23
Holopedium	0.82	0.73	1.06		0.87	0.77	6	4
Ovig. Holopedium	0.99	1.14			1.07	1.07	0	0
Sida crystalina		1.26	2.20		1.73	1.73	0	0
					Total		**420**	**345**

Appendix D.5. Zooplankton density in Sitkoh Lake, 2001

	Macrozooplankton Density (no·m^{-2})				**Seasonal mean (no·m^{-2})**
	16 May	**7 Jul**	**3 Sep**	**17 Oct**	
Station A					
Ergasilus					0
Epischura					0
Diaptomus					0
Cyclops	316,607	131,686	236,882	126,167	202,836
Ovig. Cyclops	16,556	255	2,547		4,840
Bosmina	26,745	102,649	272,118	68,263	117,444
Ovig. Bosmina	6,877	0	2,123	3,906	3,227
Daphnia l.	17,575	39,990	67,923	25,301	37,697
Ovig. Daphnia l.	9,170	2,802	5,094	3,396	5,116
Daphnia g.					0
Holopedium	6,877	3,821	15,283		6,495
Ovig. Holopedium	0	255	425		170
Chydorinae					0
Copepod nauplii		5,858			1,465
				Total	**379,288**
Station B					
Ergasilus					0
Epischura					0
Diaptomus					0
Cyclops	272,712		178,553	195,364	215,543
Ovig. Cyclops	10,358		1,783		4,047
Bosmina	9,679		97,045	135,252	80,659
Ovig. Bosmina	4,075			4,840	2,972
Daphnia l.	7,302		33,622	31,075	24,000
Ovig. Daphnia l.	6,283		4,075	4,840	5,066
Daphnia g.					0
Holopedium	7,132		6,113		4,415
Ovig. Holopedium			1,783		594
Chydorinae					0
Copepod nauplii	2,717		178,553	195,364	906
				Total	**338,201**

Appendix D.6. Zooplankton size and biomass in Sitkoh Lake, 2001.

	Body Size (mm)				Seasonal Means			
Station A	**16 May**	**7 Jul**	**3 Sep**	**17 Oct**	**Mean length (mm)**	**Weighted length (mm)**	**Biomass ($mg \cdot m^{-2}$)**	**Weighted biomass ($mg \cdot m^{-2}$)**
Cyclops	0.70	0.75	0.58	0.64	0.67	0.66	307	304
Ovig. Cyclops	0.93		0.87		0.90	0.92	14	15
Bosmina	0.47	0.50	0.48	0.48	0.48	0.48	257	259
Ovig. Bosmina	0.54	0.60	0.60	0.56	0.58	0.56	10	10
Daphnia l.	0.66	0.80	0.70	0.67	0.71	0.72	82	84
Ovig. Daphnia l.	0.88	1.01	0.95	0.96	0.95	0.93	21	20
Holopedium	0.41	0.86	0.79		0.69	0.70	30	31
Ovig. Holopedium		1.14	1.00		1.07	1.05	2	2
					Total		**724**	**724**
Station B								
Cyclops	0.61		0.63	0.63	0.62	0.62	282	280
Ovig. Cyclops	0.46		0.90		0.68	0.52	6	4
Bosmina	0.47		0.48	0.49	0.48	0.49	175	179
Ovig. Bosmina	0.53			0.56	0.55	0.55	8	8
Daphnia l.	0.68		0.80	0.69	0.72	0.74	55	57
Ovig. Daphnia l.	0.92		0.97	0.90	0.93	0.93	20	20
Holopedium	0.40		0.83		0.62	0.60	15	14
Ovig. Holopedium			0.96		0.96	0.96	6	6
					Total		**568**	**569**

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